NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

COMEL: A COMMUNICATIONS WAR GAME

by

Katherine Rowe
Robert Cecil Allgood Jr.

March 1983

Thesis Advisor: G. R. Porter

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) COMEL: A Communications War Game		5. TYPE OF REPORT & PERIOD COVERED Master's Thesis; March 1983
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Katherine Rowe Robert Cecil Allgood Jr.		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940		12. REPORT DATE March 1983
		13. NUMBER OF PAGES 325
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release, distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

COMEL
Communications War Game
Communications - Electronics War Game

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

COMEL WAR is a communications oriented wargame developed by the Joint Telecommunications Staff Officers' Course at Keesler AFB. The war game has been automated to run on a VAX/VMS computer. The program allows computer assisted play of the game using a manual gameboard.

The game has two portions, an Acquisition Phase and an Operations Phase. In the Acquisition Phase, Players budget for research and development,

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S/N 0102-014-6601

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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The programs are written in structured FORTRAN 77, with extensive comments and external documentation, so that they can be read, understood, modified, and expanded by those with limited programming experience.

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COMEL: A Communications War Game

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Submitted in partial fullfillment of the
requirements for the degree of

MASTER OF SCIENCE IN SYSTEMS TECHNOLOGY
(Command, Control, and Communications)

from the

NAVAL POSTGRADUATE SCHOOL
March 1983

ABSTRACT

COMEL is a communications oriented war game developed by the Joint Telecommunications Staff Officers' Course at Keesler AFB. The war game has been automated to run on a VAX/VMS computer. The program allows computer assisted play of the game using a manual gameboard.

The game has two portions, an Acquisition Phase and an Operations Phase. In the Acquisition Phase, players budget for research and development, manufacturing, purchase, and operations and maintenance of communications and electronic equipment for a Joint Task Force (JTF). In the Operations Phase, players allocate the available communications and electronic equipment to units, physical locations, or special missions and then direct the employment of the units and equipment in a war game.

The programs are written in structured FORTRAN 77, with extensive comments and external documentation, so that they can be read, understood, modified, and expanded by those with limited programming experience.

reports or player inputs could trigger matching write statements to the history file.

New scenarios could be developed, perhaps matching some real world situation such as the Persion Gulf. A new map and new unit and equipment lists could be developed to match the real world as closely as possible.

New equipment types, such as laser communications, satellite jammers, or airborne EW, and new unit types, such as ground recon units, could be added to the models.

The game already allows communications or EW equipment to be set up as separate mobile detachments. A module could be added to allow such a detachment to be merged back into a combat unit.

Intelligence satellites and reconnaisance flights give the location of enemy units. The module could be modified to give the type of unit (perhaps only designating it as an airfield, heqdquarters, light or heavy combat unit). The direction of movement could be derived from the goal or projected path and indicated by an approximate compass direction. The probability of detection could be varied according to the terrain or a random factor.

In a conflict situation, a commander could be given the option to pursue an enemy unit as it retreats or moves on toward its goal.

A change in the rules of engagement is immediately and automatically known to both players. A communications check between the NCA and the JTFHQ could be added before the change would take effect.

A new rule of engagement could be designed to allow commanders of major units, such as the carrier battle group, to attack on their own while requiring other units to check with the JTFHQ.

In the COMM1 modules, where equipment is allocated to missions and combat units, "idiot checks" could be added to echo each choice and provide for review and revision at the end of the module.

The intelligence module could be expanded to include general, all-source intelligence.

A greater degree of uncertainty could be included at the Umpire's request by adding random "Murphy cards", as are used in the manual game.

The line-of-sight probability model [LOSPRB] could be modified to allow more than one relay point between the unit and the JTFHQ.

An ECCM mode could be added for EW equipment.

The optimum path routine and other modules could be made more efficient.

Presently the lakes and rivers are not navigable. Changes to Subroutine PNTS could allow the amphibious task forces to navigate the rivers and lakes.

The air reconnaisance missions and airdrops are executed without any counter air or air defense opposition. These modules could be revised to include calls to the counter air module and resolution of air defense.

A Logistics Phase could be added to allow systems that are still in the R+D or M+D stages of Acquisition when the war starts to be brought into operation during the Operations Phase if proper logistics planning has been done. The Logistics Phase could include purchase and scheduling of strategic airlift. Planning for maintenance could be made to affect availability or effectiveness of systems.

V. <u>GAME PLAY REQUIREMENTS</u>

A. HARDWARE REQUIREMENTS

COMEL was developed on a Digital Equipment Corporation VAX 11/780. The operating system used is VMS. (VAX stands for Virtual Address Extension and VMS stands for Virtual Memory System.) COMEL can be run on any other system that supports FORTRAN-77 and has some type of command file executive.

The game requires three terminals; one for the Umpire and one each for the Red and Green staffs. Because of the numerous displays printed, the baud rate (speed of transmission) should be a least 1200.

The game can be played over dial up telephone connections. Telephone Modems are readily available for tranmission at this baud rate. If possible, it is more convenient to have dedicated terminals with direct connection to the host computer (these connections should also be at least 1200 baud).

Any type of terminal can be used to run the war game. The game is written to support terminal types of a generic nature. The only terminal I/O commands used are write, read, accept and type. There are no unique commands specific to a terminal type. If a hardcopy terminal is

used, the paging command may waste paper since it prints 24 blank lines. If a terminal supports a display of less than 24 lines, some messages and menus may be cut short.

B. SOFTWARE REQUIREMENTS

The VAX/VMS operating system [Ref. 4 and 5] must be used to run COMEL game as written. The,software packages required are the VAX/VMS command file interpreter and VAX-11 FORTRAN (FORTRAN-77) [Ref. 6 and 7].

Conversion to other computer systems with different operating systems, but with some dialect of FORTRAN-77, would require only minor adjustments in the programs (ie, mostly input/output routines such as open, close, type and accept). A majority of systems have some form of command file interpreter. However, the command file program would have to be transposed line by line to the new system because of the uniqueness of commands on different operating systems.

Conversion to other computer systems with different operating systems and standard FORTRAN (FORTRAN-4) would be a major project. Standard FORTRAN does not include constructs such as 'IF...THEN...ELSE' or 'DO WHILE...END DO' or character type variables. In conversion to standard FORTRAN, all the programs would have to be checked line by line and rewritten wherever non-standard FORTRAN is used. While difficult, the conversion could be accomplished.

COMEL is written (as much as possible) in structured FORTRAN in a top down approach. Maintainability and readability were prime considerations in the development of COMEL.

C. PHYSICAL REQUIREMENTS

In addition to the computer requirements discussed above, the following physical materials are needed to play the game: game boards with unit markers, scenario and mission descriptions (Operational Plans and Commander's Assesments used for the default game are attachments to the Users' Manual), and copies of the Users' Manual.

COMEL is more instructive when the Umpire, Red Players and Green Players are physically seperated. Therefore, the game should be played in three seperate rooms. The Umpire and players should have seperate maps, since the players have complete information on their forces but only partial information on their opponents.

Users' Manuals should be available to the players and umpire. COMEL requires that the Umpire and players have a good advance knowledge of the Users' Manual, which describes all the options available to the Umpire and players and the effects of each option.

The Maintenance Manual is not essential for game play but will be useful if anyone wants to know more about the models or wants to modify the game. A detailed outline of how the program is constructed can be found in the

Maintenance Manual, as well as the basic logic of each module and the parameters used by each routine. Information desired on the computer system can be found in one of the DEC Manuals; the VAX/VMS Primer [Ref. 8], VAX/VMS Command Language Users Guide [Ref. 5] and the VAX-11 FORTRAN Language Reference Manual [Ref. 6].

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APPENDIX A

COMEL USERS' MANUAL

FIGURES

ATTACHMENTS

1. INTRODUCTION

1.1 THE GAME

The purpose of Communications Electronic War (COMEL) is to allow students in communications, command and control, or related disciplines to exercise their knowledge of electronic system capabilities, the planning and acquisition processes, and the employment of communications and electronic systems in combat. Although the game does not attempt to model the exact, real time operation of the communications and electronic systems; it does attempt to realistically demonstrate the effect of electronics on the modern battlefield.

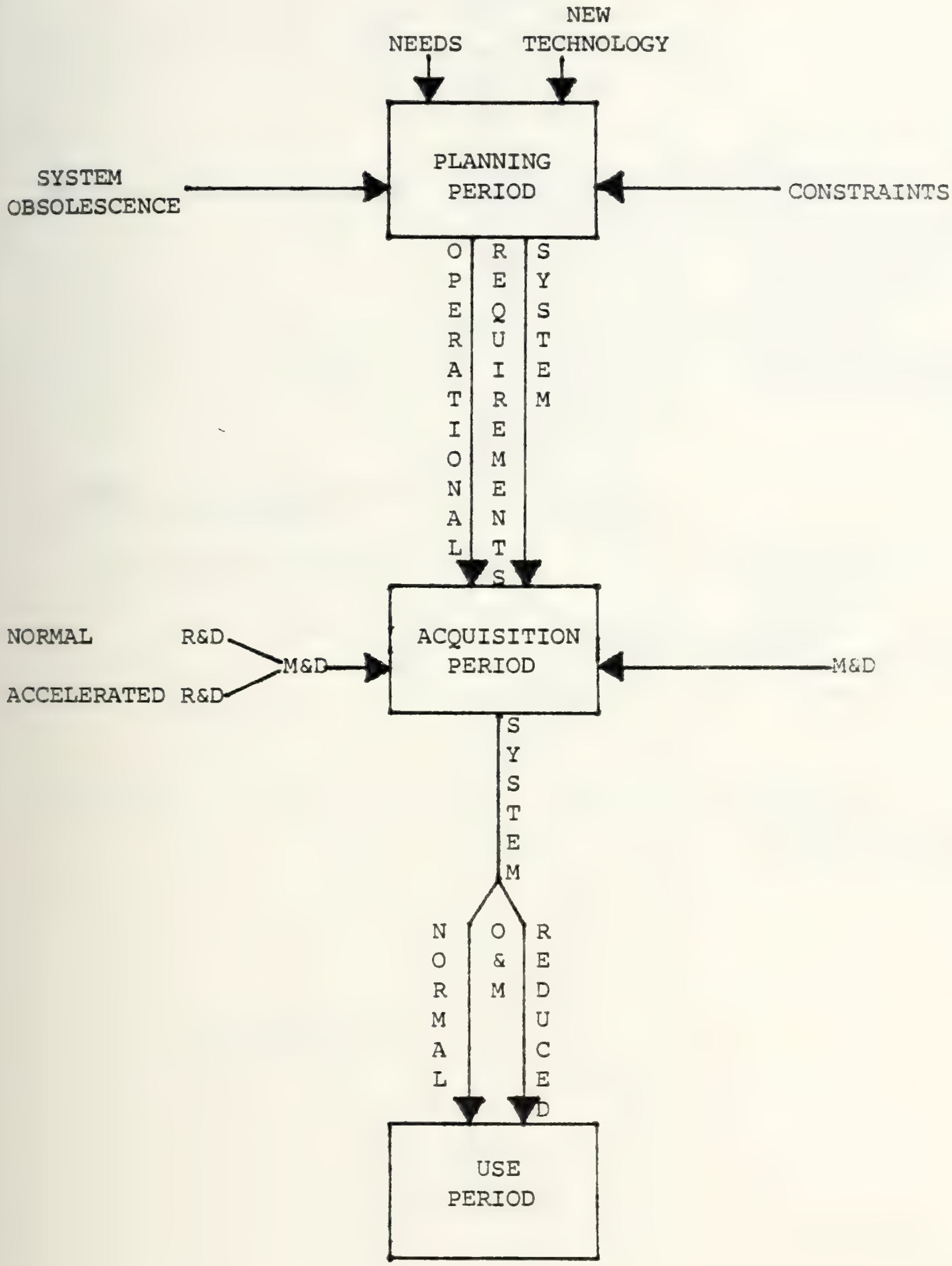
This manual gives detailed instructions for the Umpire and the players to run the game. A Maintenance Manual is also available (Appendix B) for anyone who wishes to study the construction of the models or modify the game. The main body of the thesis describes the background, uses of the game, and major models, and proposes future enhancements.

The game has two phases, an Acquisition Phase and an Operations Phase. Either may be played separately or in sequence. The game may be played in one sitting or may be saved at the end of any turn and resumed at a later time.

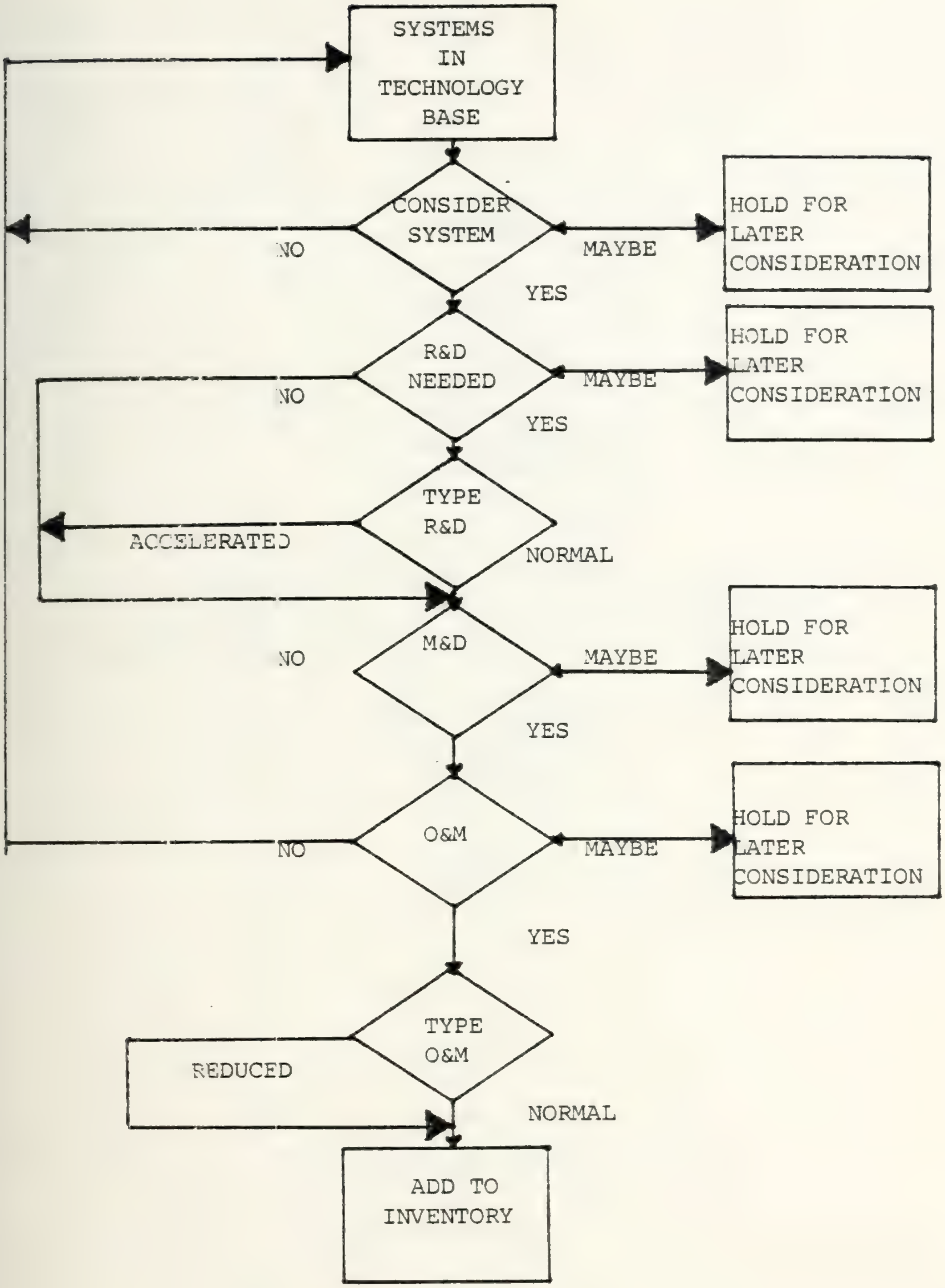
In the Acquisition Phase, players budget under time constraints for research and development, manufacturing, purchase, and operations of communications and electronic equipment for a Joint Task Force (JTF). This phase of the game traces the life cycle of electronic systems, as illustrated in Figure A-1. [Ref. 6]

In the Operations Phase, players allocate the available communications and electronic equipment to units, physical locations, or special missions and then direct the employment of the units and equipment in a war game. The war pits two approximately equivalent JTFs against each other in a race to gain control of major and minor objectives. The relative capabilities of the two sides are affected greatly by the acquisition, allocation, and employment of their electronic equipment.

Figure A-2 is a simple diagram of the sequence of the Acquisition Phase. Figure A-3 is a diagram of one turn of the Operations Phase. Figure A-4 shows the sequence of a complete, two phase game. The initial conditions of the war may be changed as different maps and objectives, different communications and electronic systems, different units, or different equipment lists are used. However, the basic sequence of the game stays the same.

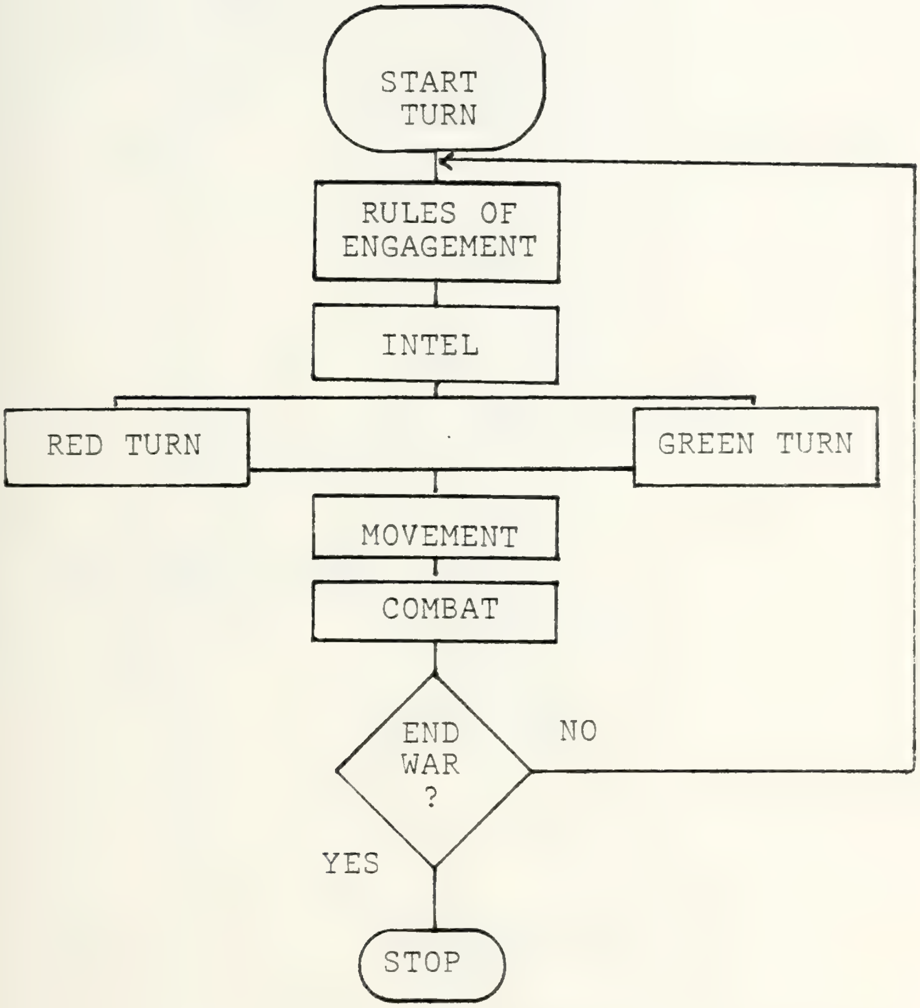


SYSTEM LIFE CYCLE
FIGURE A-1



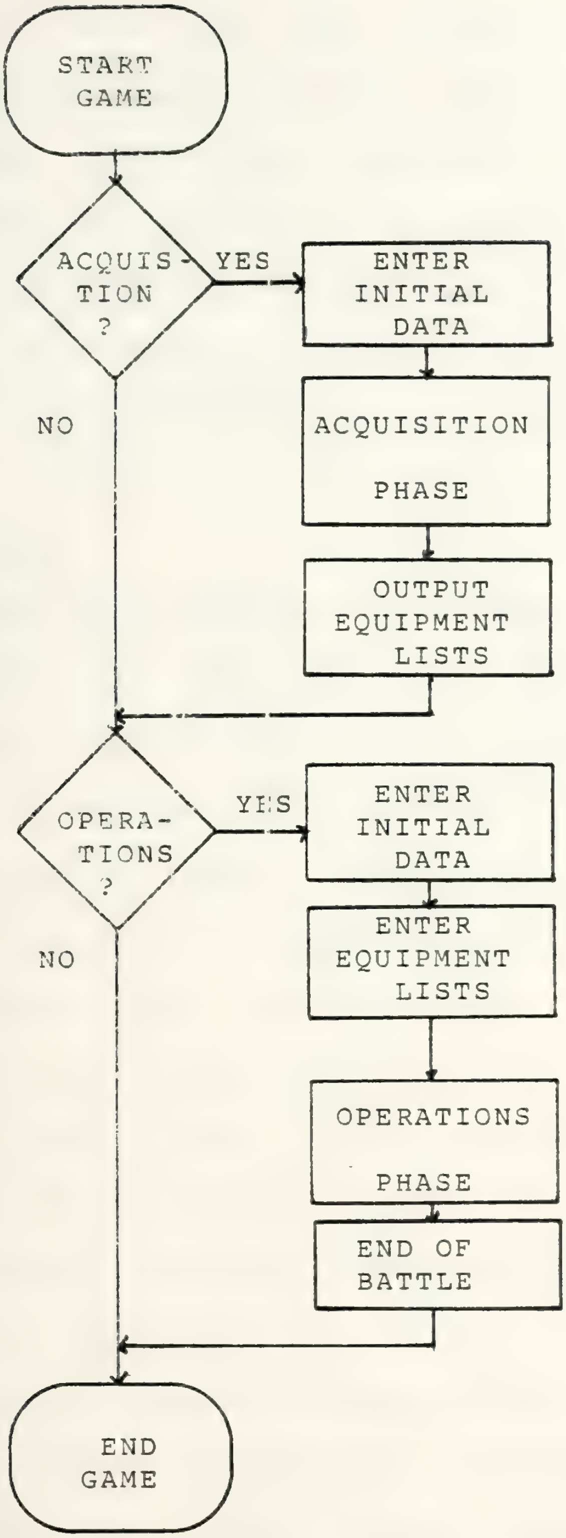
ACQUISITION SEQUENCE

FIGURE A-2



THE OPERATIONS TURN

Figure A-3



GAME SEQUENCE

Figure A-4

Instead of creating a map, objectives, communications and electronics systems, and unit lists unique to each game, a default game is provided. Detailed information on the default game may be found in Section 2 of this manual. Information on game play can be found in Sections 3 and 4. Procedures for preparing alternate versions of the game can be found in the Maintenance Manual.

1.2 THE PLAYERS

COMEL has three computer positions; the Umpire, the Green Player, and the Red Player. However, each position can and should actually be more than one person.

The Umpire has two roles. First, the Umpire controls the sequence of the game by setting the time limits for each turn and by selecting the game version to be played; for example, three turns of Acquisition using the default communications and electronics system lists, followed by ten Operations turns using the default map but alternate unit lists. Second, the Umpire takes an active role in the game play by making decisions that would normally be made at command levels above the JTF; for example, setting the annual budget for communications and electronic systems, and setting the rules of engagement. The Umpire should ideally be more than one person, since group decision making discussions provide a better learning experience.

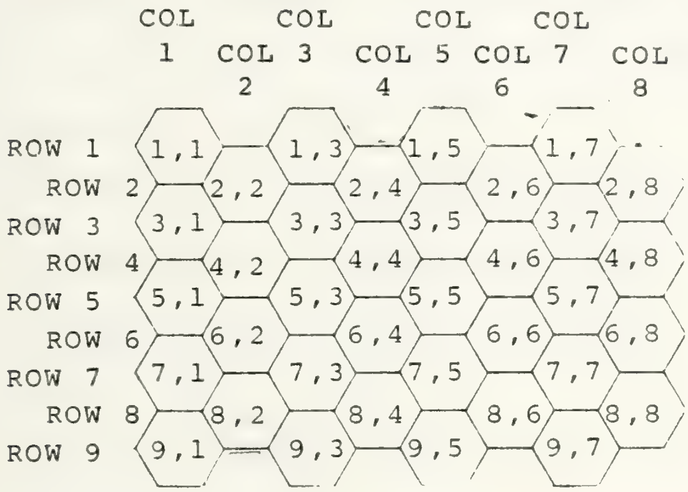
In the Acquisition Phase, the Red and Green Players act as the C3 planning staffs for their respective JTFs. During the Operations Phase they act as both the JTF staff and the direct operational commanders. Each side should ideally have at least six people: a JTF commander, a communications officer, an air support advisor, a naval-marine advisor, and two or more land combat operations advisors (who would also represent the combat unit commanders).

1.3 THE GAMEBOARD

The gameboard consists of a map translated into hexagonal divisions, hexes, in 66 rows and 60 columns. Each hex represents an area approximately five miles across, and may be designated as either open terrain, desert, mountains, woods, lake, or sea. Roads may be shown running through the hexes; rivers flow along borders between the hexes. Also located on the map are permanent features such as cities, airfields, forts, mines, major industries, or ports. The default map is illustrated in Attachment A-1 at the end of this manual. Procedures for preparing alternate maps are described in the Maintenance Manual.

The map numbering system is critical to play of the game, since players must frequently indicate locations of units, movement goals, targets, etc. by giving the hex coordinates. Hexes are numbered in rows and columns;

the row number is given first and then the column number. A segment of a hex map is shown in Figure A-5.



MAP NUMBERING SYSTEM

Figure A-5

The rows seem to alternate, with even rows staggered to the right of odd rows. This results in each hex having either two odd coordinates, like 3,5 or two even coordinates, like 4,6. No hex could be numbered 4,7 since one number is odd and one even. Hex coordinates may be entered at the terminal by separating them with either a blank space (3 5) or a comma (4,6). If counting hexes on the map, count columns by ones and rows by twos.

1.4 THE GAME PIECES (SYSTEMS AND UNITS)

The game pieces for COMEL consist of red and green markers for the units, which are moved around the map manually as the game proceeds. Symbols representing the equipment items may also be used, but that information may be kept only on paper.

Any number of units up to 19 can be entered into the game, but all units must be classified as one of eight types:

(1) Joint Task Force Headquarters (jtfhq)
(2) Tactical Fighter Wing (tfw)
(3) Carrier Battle Group (cbg)
(4) Amphibious Task Force (atf)
(5) Marine Amphibious Brigade (amph)
(6) Armored Brigade (armor)
(7) Mechanized Brigade (mech)
(8) Airborne Brigade (abn)

During the game, players may also establish communications or electronic warfare detachments ('relay' is used for the unit type in either case).

Each unit has assigned to it certain combat values. The basic combat points of a unit, CMBTP, are a measure of its ground combat capability. Each unit also has an air defense capability, ADNO. Air units (tfw and cbg) have assigned measures of their ability to overcome enemy air defenses, EWV, to give close air support, CASV, and to conduct air-to-air combat, CAV. These values are all entered as part of the initial data files.

The game will handle up to 49 different communications and electronics systems and up to a total of 99 individual end items of equipment.

Any lists of communications and electronic systems can also be used, but each individual system must be classified as one of twelve types:

(1) Tactical systems (tac)
(2) High frequency systems (hf)
(3) Line-of-sight systems (los)
(4) Communications satellites (sat)
(5) Satellite ground terminals (gtsat)
(6) Very low frequency systems (vlf)
(7) Switches (sw)
(8) Airborne command posts (abncp)
(9) Airborne radar (awacs)
(10) Electronic warfare systems (ew)
(11) Intelligence satellites (spy)
(12) Anti-satellite weapons (asat)

1.5 THE DEFAULT GAME

A default game has been developed based on the original, manual version of COMEL. The entire default game may be played or some or all of the data files may be replaced by alternate files. See the Maintenance Manual for instructions on building alternate files.

1.5.1 The Map

The default map, pictured in Attachment A-1, features Red and Green Joint Task Forces located in airfields and forts in two of their allied countries, Yellow Country and Blue Country. Between them is a neutral country, Utopia. Utopia has valuable mineral resources in

their Southern Mines, which they transport along a main highway and export through the Port of Utopia. The objective of each task force is to try to gain control of the mines, the port, and the connecting highway before the other side does. A player is considered to have control of a hex if a unit from that side was the last unit in the hex. The mines and port are considered major objectives; the road is a minor objective. Between the two sides' initial locations and their objectives lie similar terrain of mountains, woods, deserts, and lakes.

1.5.2 <u>The Systems</u>

The default game has thirty eight different communications and electronic systems of the twelve types listed in Paragraph 1.4 above. These systems are listed in Attachment A-2 with their associated technical and cost data. General descriptions of the twelve different system types are in Attachment A-3.

1.5.3 <u>The Units</u>

Each side in the default game has equivalent forces. The units, their initial locations, mobility, and combat values are listed in Attachment A-4.

1.5.4 <u>The Equipment</u>

The equipment lists include each individual end item acquired by a player. Two sets of default equipment lists are available. One set is designed for use in the Acquisition Phase and includes a very rudimentary set of

older equipment. The players use these lists as a base on which to build an adequate communications and electronic capability for the projected threat. The second set of default lists is designed for use when playing only the Operations Phase of the game. This set provides fairly adequate capabilities for the default forces. These lists can be found in Attachments A-5 and A-6.

1.5.5 The <u>Operations Plans</u>

Printed Operations Plans and Commander's Planning Guidance are also available for the default game. These documents define for the players the threat and their objectives. They give general operational guidelines, such as would be developed for real world contingency plans. These documents are Attachments A-7 thru A-10 of this manual.

2. COMMUNICATIONS AND ELECTRONIC EFFECTS

This section of the manual discusses the C3 measures of effectiveness (MOEs). Some of the measures are used by the player during the Acquisition Phase to determine the right mix of equipment to purchase. The measures are used by the computer models in the Operations Phase to compute the effect of communications and electronics systems on the battlefield.

2.1 MEASURES OF EFFECTIVENESS

Electronics capability in the game is based primarily on a measure called "C3 Effectiveness", which is a real number between 0.0 and 1.0 assigned to each communications system and most other electronic systems. In the default game, the C3 effectiveness (C3E) is a product of reliability, flexibility, and operability of the system. For communications systems the square root of the product is then taken to represent the C3E of one end of a comm link. (See thesis Chapter II, Section C.) In alternate games other measures of effectiveness could be developed and used in the system data files.

The effectiveness of a system can be affected by terrain. After each move the computer program checks the location of all equipment to see if it is effected by terrain. The affects of terrain are shown in Figure A-6.

TERRAIN TYPE	TAC	HF	LOS	SAT
		COMM SYSTEM		
Open	none	none	none	none
Desert	Degrades all systems 20%			
Woods	1/2 Range	Degrades GW 20%	none	none
Mountains	Range 1 hex	Degrades GW 40% SW 20%	Note 1	none
Seas/Lakes	Degrades 15%	Degrades 20%	Degrades 15%	none
Cities	Degrades 20%	Degrades GW 40% SW 20%	Degrades 15%	none

GW = HF in Ground Wave Operation
SW = HF in Sky Wave Operation

Note 1: LOS transmission is degraded by mountains in the path. The model uses the optimum path to simulate line-of-sight and checks the path for mountain hexes. Two or more hexes located less than three hexes from the unit's end of the path will block LOS links completely. If the mountains are three hexes from the end they will degrade the link 25%

TERRAIN EFFECTS ON COMMUNICATIONS

Figure A-6

The effectiveness of a system may be affected by enemy jamming. Prior to combat, the program checks any electronic warfare equipment in the Electronic Countermeasures (ECM) mode to see if it is in range of any enemy communications gear that it is effective against. If so, the C3E of the communications equipment is muliplied by a factor of 0.75.

Communications connectivity of units is calculated in three functions, based on the C3E of collocated equipment:

(a) INTC3 is a measure of a unit's ability to communicate internally. The value depends primarily on the effectiveness of the tactical communications equipment assigned to the unit. If n items of tactical equipment are assigned to a unit, the unit's INTC3 is calculated as:

INTC3 = 1 - [(1 - C3E(1))*(1 - C3E(2))*...(1 - C3E(n))]

The higher the internal communications value, the faster a unit can move and the better it can fight.

(b) C3EXT is a measure of a unit's ability to communicate with the Joint Task Force Headquarters. Links can be established through satellites, through HF (either ground wave or skywave depending on range), through line-of-sight systems (in direct range or through one relay), and even through tactical systems (only at very close range). For a link to be effective, both the unit and the JTFHQ must have compatible equipment. Some equipment is compatible only if located in the same hex or if connected by wire within the same hex. (See Attachment A-2f.)

The basic formula for calculating C3EXT is:

C3EXT = 1 - [(1-HFPROB)*(1-GTPROB)*(1-LOSPRB)*(1-TACPRB)]

These probabilities are products of the C3E of systems in the link. HFPROB is the probability of an HF link, GTPROB of a satellite link, LOSPRB of a line-of-sight link, and TACPRB of a tactical link. The communications links for a typical unit are shown in Figure A-7, along with calculation of its C3EXT. The C3E values are from the default game.

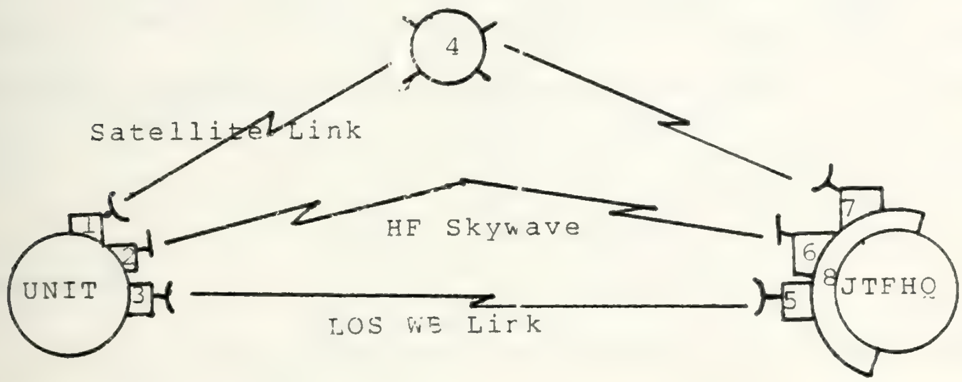


DIAGRAM NUMBER		EQUIPMENT		C3E
Equipment #3 and #5	-	wb 1	-	c3e = 0.787
Equipment #2 and #6	-	hftty 1	-	c3e(sky wave) = 0.608
Equipment #1 and #7	-	shf-gt	-	c3e = 0.819
Equipment #4	-	shf-sat	-	c3e = 0.67
Equipment #8	-	tritac	-	c3e = 0.95

LINK PROBABILITIES

LOS Link Probability = #8 * #3 * #5 = .588
HF Link Probability = #8 * #2 * #6 = .351
Satellite Link Prob. = #8 * #1 * #4 * #7 = .427

C3EXT = 1 -[(1-.588)(1-.351)(1-.427)] = 0.847

CALCULATION OF EXTERNAL C3 EFFECTIVENESS

Figure A-7

(c) NCACON is a measure of the JTFHQ ability to communicate with the National Command Authority (NCA) or any other CONUS based unit via satellite, HF, and/or VHF links. Its computation is similar to C3EXT except the NCA is assummed to have 100% effectiveness in VLF, HF, and satellite ground terminals. Only certain communications systems are compatible with NCA systems. The players must purchase and/or allocate communications systems effectively to get good values for all three of these communications measures (INTC3, C3EXT, AND NCACON). These three measures affect many aspects of the Operations game, as described below.

2.2 MOVEMENT

A unit will not begin to move across the game map, or change the goal (destination) of its movement unless ordered to do so by the JTFHQ. To determine whether a movement order can get to a unit, the unit's C3EXT is compared to a uniform (0,1) random number.

Each unit has a basic number of movement points per turn, based on the type of unit (armor, infantry, headquarters, etc.). This movement rate is initially set in the data files but can be reduced by terrain; for example, movement through mountains takes more points (3) than movement through open terrain (1), but roads allow faster movement (1/2). The movement rate is also affected by the

mobility of any electronic equipment the unit is carrying along with them. If any communications or electronic equipment the unit is carrying has less mobility than the unit, the unit must slow down. Poor internal communications can also slow down unit movement. The INTC3 value of the unit is compared to a random number; if the random number is larger the movement points of the unit are reduced by a half. (See Figure A-6 in Section 2.6 for details of the terrain effect on movement points.)

2.3 INTELLIGENCE

Intelligence satellite information cannot be passed to the JTFHQ unless there is connectivity from the CONUS (NCACON). Air reconnaissance requires connectivity from the JTFHQ to the air wing (C3EXT).

2.4 ATTACK APPROVAL

The Umpire, acting as the NCA, selects the rules of engagement at the beginning of the Operations Phase and can change them during the game. There are three levels of engagement: the NCA may retain tight control of the war, may delegate authority to the JTF Commander, or may give control to local field commanders. For example the NCA or JTF may want to maintain attack approval to ensure that the other side initiates hostilities, or to coordinate the timing of a preemptive, force-wide attack.

The NCA does not delegate control of the anti-satellite weapons. If the NCA retains control, connectivity from the unit involved to the JTFHQ and to the NCA is checked for every decision to attack, on the ground or from the air. If control is delegated to the JTF Commander, only unit-JTFHQ connectivity is checked before an attack. If the local commander has control, connectivity is necessary only for air support.

Approval level is determined and necessary communications checks made before anti-satellite firings, interdiction missions, or ground attacks begin. (Close air support, air defense, and counter air missions occur only in conjunction with interdiction or ground attacks, and so are also dependent on the rules.)

2.5 THE AIR BATTLE

Close air support and interdiction missions require connectivity to the air wing and internal communications for the wing. Counter air requires good internal communications within the air wing. If the enemy unit has AWACS, counter air interceptors are warned in time to attack interdiction or close air support missions enroute; without AWACS the interception takes place after the support mission is completed.

Counter air battles are resolved by subtracting the counter air values (CAV) of both sides and comparing the difference to a random number. An internal table, based on the one in Figure A-8, determines the outcomes.

GREEN CAV - RED CAV

		4	3	2	1	0	-1	-2	-3	-4
	0	GL	GL	GL	GL	GL	GL	GL	GL	GL
R N	1	-	G	GL	GL	G	GL	GL	GL	GL
A U	2	X	-	G	G	G	GL	GL	GL	GL
N M	3	R	X	-	-	-	G	GL	GL	GL
D B	4,5	RL	R	R	X	X	X	G	G	GL
O E	6	RL	RL	RL	R	-	-	-	X	G
M R	7	RL	RL	RL	RL	R	R	R	-	X
	8	RL	RL	RL	RL	R	RL	RL	R	-
	9	RL	RL	RL	RL	RL	RL	RL	RL	RL

- Standoff; Both sides continue mission
X Both sides abort missions
R Red aborts
G Green aborts
RL Red aborts with attrition
GL Green aborts with attrition

COUNTER AIR RESULTS TABLE

FIGURE A-8

Close air support (CAS), if not stopped by the counter air forces, subtracts the air wing's electronic warfare value from the ground unit's air defense value. The difference and a random number are compared using the table in Figure A-9 to determine the outcome. If the CAS mission is not aborted, the ground unit's combat value is reduced by 1.0.

AIR DEFENSE VALUE - EW VALUE
(Ground Unit)   (Air Unit)

		1	2	3	4	5
RANDOM NUMBER	0,1	N	N	N	N	N
	2,3	N	N	N	N	A
	4,5	N	N	A	A	AA
	6,7	A	A	A	AA	AA
	8,9	A	AA	AA	AA	AA

N = No effect
A = Aircraft abort mission
AA = Aircrift abort with attrition

AIR DEFENSE RESULTS TABLE

Figure A-9

Interdiction missions also must go through counter air and air defense battles, as described for CAS. If the mission is not aborted, the ground unit's combat value is also reduced by 1.0.

2.6 THE GROUND BATTLE

Each ground unit has a certain ground combat capability that may or may not have been reduced by interdiction or close air support. Higher headquarters approval may be needed for a ground attack (NCACON and C3EXT). Poor tactical communications may decrease the ability of a local commander to direct the movement and other actions of his

forces during the battle (INTC3). Terrain also affects combat capability as shown in Figure A-10.

TERRAIN TYPE	MOVEMENT COST IN MOBILITY POINTS	COMBAT EFFECT IN COMBAT POINTS
Open	-1	none
Highway	-1/2	none
Desert	-1	+1 for attacker
Woods	-2	+1 for defender
Mountains	-3	+2 for defender
Seas	-1 (ships only)	none
Lakes	-999 (no movement)	none
Rivers	-1 (when crossing)	+1 if defending behind
Cities	-1	+1 for defender

TERRAIN EFECTS ON MOVEMENT AND COMBAT

Figure A-10

2.7 ELECTRONIC WARFARE

Electronic warfare equipment may be used in two modes, ESM (Electronic Support Measures) and ECM (Electronic Counter Measures). In the ESM mode, it can give bearings to compatible enemy emitters, as intelligence information, improving planning and local combat direction. In the ECM mode it can jam or deceive susceptable communications, degrading the effectiveness of enemy systems. In ground

combat, equipment in the ESM mode can detect and possibly intercept or deceive enemy communications. If so, the owning unit's combat points are increased by the EW factor of the equipment.

2.8 SPECIAL EQUIPMENT

Special equipment, such as satellites, anti-satellite weapons, AWACS, and Airborne Command Posts can greatly increase the capabilities of the combat forces through intelligence, communications relay, or by degrading enemy capabilities.

Communications satellites are of two types, those with one area beam and those with several spot beams. Ground terminals that are compatible are always in range of area beam satellites. However, when using spot beam satellites, the players must reposition the spot beam centers so that the ground terminals can use the satellite.

Intelligence satellites survey a north-south strip of the map. The width of the strip depends on the beamwidth of the satellite. The columns to be surveyed can be changed once each turn. The effectiveness (C3E) is less than 100% (there may be cloud cover or the satellite may not be working), but when the satellite is working it detects any enemy unit in the strip it surveys.

Anti-satellite weapons can only be used once, against either a communications or an intelligence satellite. Only one weapon may be used in a turn. Each weapon has a given C3E. If the NCA approves the use of a weapon, the C3E and a random number are used to determine whether the attack is successful.

AWACS and ABNCP operate on scheduled rotations. No more than one of each is in orbit for a turn. If less than three of each were purchased, they may not be available at all times. If they are available, and don't break down at the last minute, their orbit can be set for each turn. They can act as communications relays and the AWACS can detect interdiction and close air support attacks and call up counter air to stop them.

3. UMPIRE GAME PLAY

3.1 INTRODUCTION

This section describes COMEL from the Umpire's perspective and lists the possible options and their consequences to game play. Section 4 describes the game in the same way from the Green and Red Players' perspective.

The following subsections describe:

a. The procedure used to LOGIN on the VAX/VMS computer and start COMEL.

b. The steps the Umpire should follow to successfully setup and run various versions of COMEL.

The Umpire is an active participant in COMEL and not just an observer. An amount of preplanning is necessary to ensure a smooth and well run game. The Umpire should plan for how long the total game will take and divide the game turns accordingly. It might be necessary to play the game over a period of more than one day or at least in more than one session at the terminal. The Umpire is also responsible for allocating money in the Acquisition Phase and supplying intelligence information. In the Operations Phase, the Umpire makes decisions based on Red or Green requests and upon how the game is proceeding.

This section of the manual will discuss in detail the various decisions for which the Umpire is responsible.

3.1.1 Logging In and Running COMEL

Any terminal connected to the VAX/VMS system can be used to run COMEL. Just turn the terminal on and press the return key. If everything is in working order, the computer should display the word, USERNAME: . In response to USERNAME: , enter the LOGIN name provided (eg, COMEL) and press return. The computer will display PASSWORD. Enter the PASSWORD provided then press the RETURN key. If the message "User authorization failure" is displayed, check to see that you have the correct username and password, press the return and try again.

After a successful LOGIN, the computer will prompt for USER input with a "$ ".

To run COMEL, input the following item (without quotation marks):

"@COMEL"

Then press the RETURN key (hereafter, <RET >), and COMEL GAME OPTION MENU will be displayed.

3.2 UMPIRE OPTIONS

The following MENU displays the initial actions that are available to the Umpire at the start of each game, during certain stages of the play of the game, and at the conclusion of play of each game. The Red and Green Players

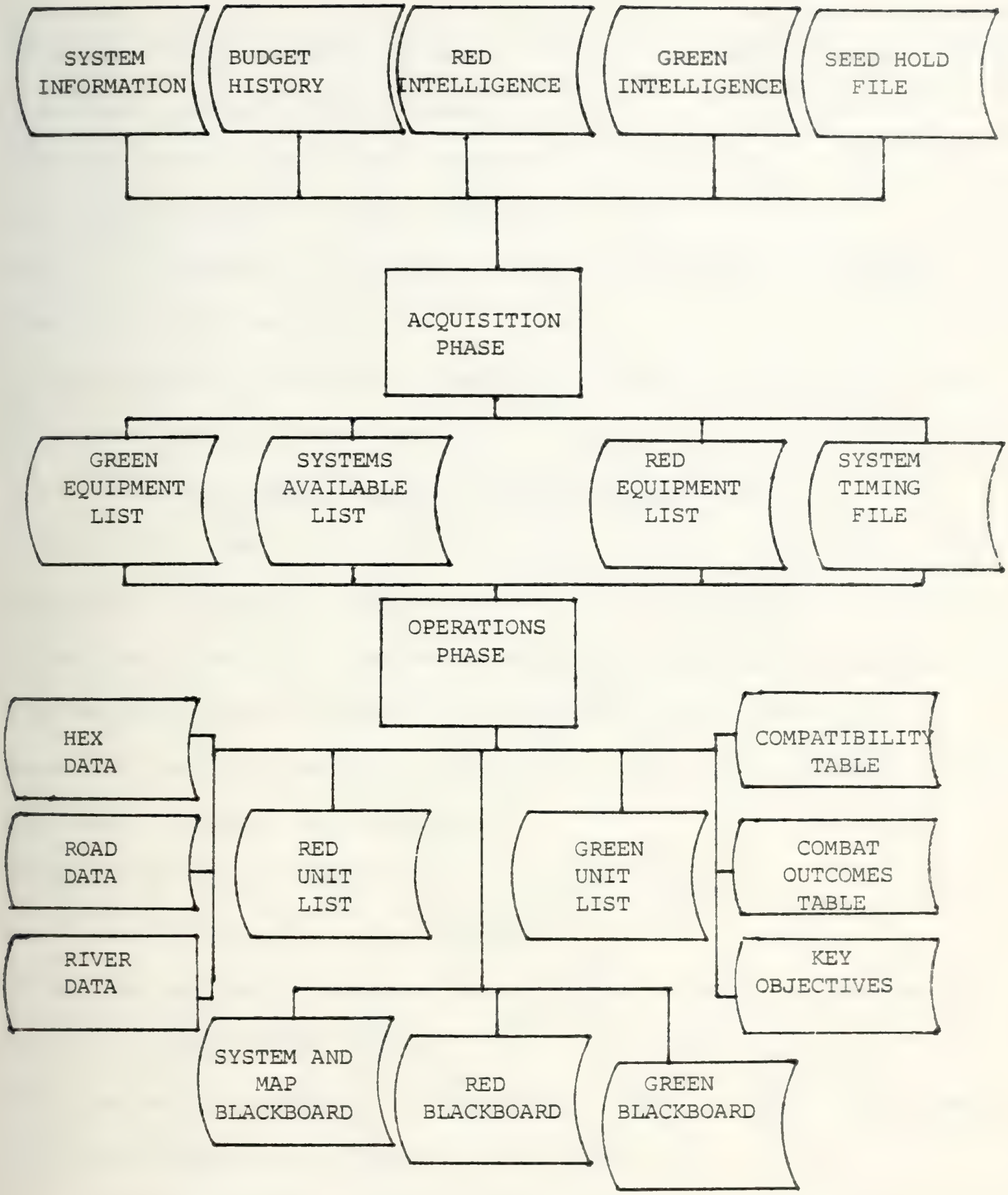
should not be signed on at this time (or at least not past the COMEL ACQUISITION game header display described in Section 4).

```
COMEL WAR GAME OPTIONS
----------------------
! CHOOSE: ##         !
----------------------
##  ACTION REQUIRED
--  ------------------------------------------------
 1  NEW GAME : DEFAULT  DATA/EQUIPMENT FILE EMPTY
 2  NEW GAME : DEFAULT  DATA/OPERATIONS  START
 3  NEW GAME : DEFAULT  DATA/ACQUISITION START
 4  OLD GAME : CONTINUE DATA/DESIGNATED SAVE AREA
 5  MOD GAME : TAILOR   DATA FILES
 6  SAVE   GAME
 7  DELETE GAME
 8  DELETE FILE
 R  START  GAME
 E  EXIT   COMEL
```

Enter one of COMEL options in this menu. Described next are the effects of each option. The purpose of this menu selection is to run COMEL, or to save, delete or modify the files used by the game. See the attached Figure (A-11) for the architecture of the files.

3.2.1 <u>New Game: Default Data/Equipment File Empty</u>

All COMEL system files are loaded with the data necessary to run the game. The equipment list files are empty, which means the players start the Acquisition Phase with no existing equipment. The players acquire all the electronic equipment they need to operate the forces in the projected scenario. All electronic equipment will have to be procured and placed in service through the acquisition process.



COMEL FILE ARCHETECTURE

FIGURE A-11

When option 1 is selected and while the appropriate files are being loaded, the message

SETTING UP NEW GAME: WAIT PLEASE

will be displayed at the terminal.

After successfully setting up the game files, the message

GAME FILES ARE READY [C/R]

is displayed. Respond by pressing <RET>. The main menu will then appear and COMEL can be run.

3.2.2 <u>New Game: Default Data/Operations</u>

All COMEL system files are loaded with the data necessary to run the game starting at the Operations Phase. A sufficent set of electronic equipment has been provided to the Red and Green Players for adequate communications.

When option 2 is selected and while the appropriate files are being loaded, the message

SETTING UP NEW GAME: EXTENSIVE, WAIT PLEASE

will be displayed at the terminal.

After successfully setting up the game files, the message

GAME FILES ARE READY [C/R]

is displayed. Respond by pressing <RET>. The main menu will then appear and COMEL can be run.

3.2.3 <u>New Game: Default Data/Acquisition Start</u>

The COMEL files are loaded with a standard set of data for games that intend to exercise the Acquisition Phase and the Operations Phase. The Acquisition Phase is not

started with a "clean slate" of equipment. Realistically, we never start procuring for future defense needs without "current defense capability". There is always a curent defense capability. However, as new threats are perceived and new technologies emerge, acquisition plans are developed and executed to modernize forces to meet these threats. In this case, the Red and Green equipment files will contain a set of hypothetical default equipment that satisfies the current threat scenarios. Various acquisition strategies can be explored using this common starting point so that a successful stategy can be found that will meet the potential threat (and eventual war).

As before, the message

SETTING UP NEW GAME: MINIMAL, WAIT PLEASE

will be displayed at the terminal.

After successfully setting up the game files, the message

SETUP FINISHED [C/R]

is displayed. Respond by pressing <RET>. The main menu will then appear and COMEL can be run.

3.2.4 Old Game: Continue Data/Designated Save Area

Selecting this option will cause the following menu to be displayed:

```
----------------------
| OLD GAME SELECTION |
| CHOOSE:  ##        |
----------------------
   ##  ENTER SAVED WAR GAME
   --  --------------------
    0  EXIT SAVED GAMES
    1  COMEL WAR GAME 1
    2  COMEL WAR GAME 2
    3  COMEL WAR GAME 3
    4  COMEL WAR GAME 4
    5  COMEL WAR GAME 5
    6  COMEL WAR GAME 6
    7  COMEL WAR GAME 7
    8  COMEL WAR GAME 8
    9  COMEL WAR GAME 9
```

This option assumes that a war game played earlier has been saved to one of these nine areas. Selecting a -0- will force an exit back to the main menu without affecting any COMEL files. Should a 1 through a 9 be selected, all files for that war game will be restored to the same state they were in when saved previously with the SAVE GAME option. After restoration, the main menu will appear and COMEL can be run. A wait message will appear while files for the appropriate game are being loaded.

3.2.5 Mod Game: Tailor Data Files

Selection of option -5- assumes a knowledge of the operation, program and data flow of COMEL. With this option, the war game can be tailored to specification at the FILE level. That is, a war game can be set up with a different system data file than standard, or with a Red equipment file from one game and a Green equipment file from another game. The same electronic equipment used in one scenario can be used in a different scenario to see what

changes will result in the game (ie, change the MAP for the Operations Phase). There are an unlimited number of combinations that can be made by using this option to tailor files. The Thesis and Maintenance Manual should be read and understood prior to setting up tailored files.

There will be a series of self explanatory questions dealing with files to be used. Answer each question 'yes' or 'no'. If yes, a file name will be requested.
If no, the default for that file will be used. After files are set up,
END OF TAILORED FILES,[C/R]
is displayed. Respond by pressing <RET>. The main menu will then appear and COMEL can be run.

3.2.6 Save Game

The selection of -6- will result in the following menu:

```
-----------------------
! SAVE GAME TO FILE   !
! CHOOSE:  ##         !
-----------------------
   ##  ENTER GAME AREA FOR SAVE
   --  ------------------------
    0  EXIT  GAME SAVE ROUTINE
    1  COMEL WAR GAME 1
    2  COMEL WAR GAME 2
    3  COMEL WAR GAME 3
    4  COMEL WAR GAME 4
    5  COMEL WAR GAME 5
    6  COMEL WAR GAME 6
    7  COMEL WAR GAME 7
    8  COMEL WAR GAME 8
    9  COMEL WAR GAME 9
```

Using this option, all game files used in COMEL will be saved to one of these nine areas. Option -0- will cause a

return to the main menu without affecting any COMEL files. A -1- through -9- will save the COMEL files prefixed with the SAVE GAME number selected. The main menu will then appear for further action. When a save file is selected, new versions of all files in that area are created so that information in old files is not lost.

3.2.7 Delete Game

A directory listing of all files for war game -1- through war game -9- will be displayed at the terminal. After the directory listing the display

GAME TO BE DELETED?[1-9]

is given. Enter a <RET> to go back to the main menu or enter the war game to be deleted. Then the following will be displayed:

VERSION # [IE NUMBER AFTER ;]

Input the specific version number to delete the game (1,2,3 etc). A <ret> with no number will result in the main menu. Assuming a correct version is entered, displayed next is:

END OF DELETE?[Y/N]

If 'n' is entered, another game can be deleted without first returning to the main menu. 'y' returns directly to the main menu.

3.2.8 Delete File

A directory listing of war game files is displayed. Any file displayed on the terminal can be deleted by correctly specifying its game, version # and file name.

After the directory listing,

GAME TO BE DELETED?[1-9]

is displayed. A file under that war game will be deleted, not the entire game. If a <RET> is entered, control will be passed to the main menu.

VERSION # [IE, NUMBER AFTER ;]

Input the version number of the file to delete (1,2,3, etc). A <RET> will result in control passing to the main menu. Assuming a version # is entered,

FILE?(REQUIP,RINTEL, ETC)

Enter the file that is to be deleted. If a <RET> is entered, control will be passed to the main menu. If a correct Game, Version and File name are entered, the next display will be

END OF DELETE?[Y/N]

Another game can be deleted if "yes" is entered.

3.3 START GAME

The administrative initialization of the game is now complete and, with option -R-, the actual COMEL war game (UMPIRE.FOR) now begins. IF a CONTROL Y (a panic exit) is entered in any module under UMPIRE control, the game will be stopped, and control will pass to the initial menu (Section 3.2). Variables in arrays will not be saved, but all files will be at the same state they were in prior to the CONTROL Y (ie, only the current turn information will be lost). The

4.5 PREPARING FOR THE OPERATIONS PHASE

This section of the manual describes the assignment of equipment to units. The steps of an Operations turn are described in the next section. Figure A-14 provides an overview of both sections.

The first step in preparing for the Operations Phase is advanced planning. The players should have available copies of the map, their unit lists, their equipment lists, a general operations plans. (See Attachments A-1 through A-10 for default versions.) The players should set up the map, using movable markers to indicate the locations of the units. They should plan the allocation and employment of their equipment to best support their forces and the coming operations. They should prepare a list of the equipment assignments and may want to prepare network diagrams.

The players should not go past this logo until told to do so by the Umpire:

```
*********************************************************
*                                                       *
*     ****     ****     *     *    ******    *          *
*    *    *   *    *    **   **    *         *          *
*    *        *    *    *  *  *    *****     *          *
*    *    *   *    *    *     *    *         *          *
*     ****     ****     *     *    ******    ******     *
*                                                       *
*              ****     *****       ****                *
*             *    *    *    *     *                    *
*             *    *    *****       ****                *
*             *    *    *          *    *               *
*              ****     *           ****                *
*                                                       *
*********************************************************
```

Do not proceed past this point until told to do so by the Umpire. When the Umpire tells you to go on, enter [C/R]

Attachment A-2c

DEFAULT SYSTEMS TECHNICAL DATA

#	SYSTEM	ETYPE	MOB	CRNG (BMWD)	CRNGS	SEC	REL	RELS	FLEX	OPT	C3E	C3ES
1	artac 1	tac	7	3	1		0.780		0.750	0.880	0.714	
2	artac 2	tac	8	4	3		0.950		0.900	0.950	0.900	
3	navtac 1	tac	7	3	1		0.820		0.830	0.880	0.775	
4	navtac 2	tac	8	5	3		0.960		0.920	0.960	0.922	
5	aftac 1	tac	7	3	1		0.830		0.830	0.860	0.922	
6	aftac 2	tac	8	5	3		0.950		0.910	0.950	0.906	
7	hftty 1	hf	8	6	9999	2	0.930	0.680	0.825	0.880	0.550	0.608
8	hftty 2	hf	8	9	9999	3	0.980	0.680	0.883	0.900	0.690	0.693
9	wbs 1	los	7	35	2		0.850		0.830	0.880	0.787	
10	wbs 2	los	8	50	3		0.900		0.900	0.930	0.866	
11	shf-sat	sat	999	9999	1	4	0.990		0.850	0.800	0.67	
12	shf-gt	gtsat	8	9999	4		0.990		0.850	0.800	0.819	
13	vlf	vlf	0	9999	3		0.980		0.850	0.950	0.610	
14	tritac	sw	4	0	4		0.990		0.980	0.980	0.950	
15	tritaceh	sw	5	0	4		0.990		0.990	0.990	0.970	
16	sat 1	sat	999	9999	1	1	0.850		0.800	0.900	0.610	
17	gt-sat 1	gtsat	0	9999	1		0.850		0.800	0.900	0.781	
18	sat 2	sat	999	9999	1	2	0.950		0.900	0.900	0.770	
19	gt-sat 2	gtsat	0	9999	2		0.950		0.900	0.900	0.877	
20	sat 3	sat	999	10	4	4	0.850		0.980	0.900	0.770	

ETYPE = Equipment type
MOB = Mobility (Movement points)
CRNG(BMWD) = range(beamwidth of satellites)
CRNGS = range of HF in skywave mode
SEC = Security Factor (resistance to EW)
REL = Reliability
RELS = Rel. of HF in skywave
FLEX = Flexibility
OPT = Operability
C3E = C3 Effectiveness

Attachment A-2d

DEFAULT SYSTEMS TECHNICAL DATA (Continued)

#	SYSTEM	ETYPE	MOB	CRNG (BMWD)	CRNGS	SEC	REL	RELS	FLEX	OPT	C3E	C3ES
21	gt-sat 3	gtsat	0	10	4		0.850		0.980	0.900	0.866	
22	singars	sat	999	6	6	5	0.950		0.980	0.930	0.780	
23	singargt	gtsat	8	6	5		0.950		0.980	0.930	0.883	
24	abncp 1	abncp	999	40	3		0.800		0.850	0.800	0.540	
25	abncp 2	abncp	999	9999	4		0.880		0.930	0.830	0.760	
26	awacs	awacs	999	9999	3		0.880		0.800	0.830	0.580	
27	awacs-eh	awacs	999	9999	4		0.950		0.850	0.830	0.670	
28	spysat 1	spy	999	1	2		0.880		0.830	0.850	0.620	
29	spysat 2	spy	999	2	3		0.980		0.900	0.850	0.750	
30	atksat 1	asat	0	9999			0.950		0.850	1.000	0.810	
31	atksat 2	asat	0	9999			0.970		0.900	1.000	0.870	

ETYPE = Equipment type
MOB = Mobility (Movement points)
CRNG(BMWD) = range(beamwidth of satellites)
CRNGS = range of HF in skywave mode
SEC = Security Factor (resistance to EW)

REL = Reliability
RELS = Rel. of HF in skywave
FIFX = Flexibility
OPT = Operability
C3E = C3 Effectiveness
C3ES = Eff. of HF in skywave

Attachment A-2e

EW SYSTEMS TECHNICAL DATA

#	SYSTEM	ETYPE	MOB	CRNG	EWV	ECM	ESM
32	ew 1	ew	8	4	6	-0.400	2
33	ew 2	ew	8	5	8	-0.500	2
34	ew 3	ew	6	6	7	-0.500	1
35	ew 3a	ew	99	10	10	-0.600	1
36	ew 4	ew	8	4	7	-0.500	1
37	ew 4a	ew	99	4	10	-0.500	1
38	ew 5a	ew	99	3	10	-0.750	1

ETYPE = Equipment type
MOB = Mobility
CRNG = Range
EWV = EW value, ability to overcome security of comm systems, larger number is better
ECM = Jamming power, effect on comm systems C3E, a smaller, more negative number is better
ESM = ability to detect and intercept comm systems,a larger number is better

DEFAULT COMPATIBILITY TABLE

System Numbers (from system list)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	CA
1	T		T		T									W	W									T		T						T	T						
2		T		T		T								W	W										T		T					T	T						
3	T		T		T									W	W									T		T						T	T						
4		T		T		T								W	W										T		T					T	T						
5	T		T		T									W	W									T		T						T	T						
6		T		T		T								W	W										T		T					T	T						
7							T							W	W									T		T										T	T		T
8								T						W	W										T		T									T	T		T
9									T					W	W									T		T								T	T				
10										T				W	W										T		T							T	T				
11												T													T													T	
12											T	T			W					T																			
13													T	W	W																								T
14	W	W	W	W	W	W	W	W	W	W			W	W			T		T																				
15	W	W	W	W	W	W	W	W	W	W		W	W		W		T		T		T		T																
16																	T							T															T
17														G	G	T																							
18																			T						T														T
19														G	G			T																					
20												T									T				T													T	T
21															G					T																			
22																							T		T								T						
23															G							T																	

BLANK = NOT COMPATIBLE W = COMPATIBLE ONLY THROUGH WIRE CONNECTION
T = COMPATIBLE G = COMPATIBLE ONLY IN SAME HEX

Attachment A-3a

SYSTEM INFORMATION

Service Tactical Communication systems (tac) are designed for internal unit comm in support of unit operations. They are compatible with other tactical comm systems of the same generation (when in range).

High Frequency Systems (hf) can be used in both surface and skywave modes of propagation. Each system is compatible with the airborne comm systems of the same generation.

Wide Band systems are compatible with airborne comm systems within range and type restrictions. They are line-of-sight systems (los).

Switching Systems (sw) interface comm systems into the unit command center. They are normally used only at the JTFHQ.

Satellite systems consist of a satellite (sat) and fixed earth terminals (gtsat). Each system may be compatible with either an airborne comm platform or other satellite systems. The SINGGARS system provides very mobile single channel comm between distant tactical units but is limited in compatibility to the ABNCP II. The SHF system consists of a satellite and mobile earth terminals. The SHF earth terminals may also use the SATCOM III satellite.

VLF System (vlf) is a Very Low Frequency System designed to provide anti-jam comm with the NCA.

Airborne Command Posts (abncp) are airborne comm platforms that can interface with a large number of other comm systems to provide redundancy and a greater range capability.

Airborne Warning Control System (awacs) provides some interface with other comm systems as well as an advanced radar warning system which detects enemy aircraft movement.

Attachment A-3b
SYSTEM INFORMATION (Continued)

Intelligence satellites (spy) are used to detect ground movement. The SPYSAT I can detect movement in a 1 hex strip. SPYSAT II can detect movement in a 2 hex strip. Each satellite may be positioned once during each Operation turn.

Anti-Satellite Systems (asat) are not comm systems. They are weapons systems to be used against enemy intelligence satellites and enemy communications satellites. ATK SAT may be used only once and their use must be approved by the NCA.

EW systems (ew) are ground-mobile systems effective against various types of comm systems. The EWF of a system measures its ability to overcome the security of communications systems. ECM measures its jamming power, or effect on the comm system's C3E. ESM measures its ability to detect and intercept comm systems.

Attachment A-3b

Attachment A-4

RED DEFAULT UNITS

unitname	type	location	mob	ewv	casv	cav	adno
jtfhq	jtfhq	54 54	4	0	0	0	6
24th tfw	tfw	4 56	0	6	6	4	4
86th tfw	tfw	29 55	0	6	4	6	4
7th cbg	cbg	3 39	8	0	0	0	4
21 atf	atf	5 43	8	6	4	6	6
8th mab	amph	6 44	6	0	0	0	5
297 arbg	armor	29 55	8	0	0	0	4
81 arbg	armor	54 54	8	0	0	0	4
41 mech	mech	54 54	8	0	0	0	4
8th abn	abn	4 56	4	0	0	0	3

GREEN DEFAULT UNITS

unitname	type	location	mob	ewv	casv	cav	adno
jtfhq	jtfhq	57 7	4	0	0	0	6
6th tfw	tfw	6 4	0	6	6	4	4
31st tfw	tfw	37 5	0	6	4	6	4
4th cbg	cbg	2 22	8	0	0	0	4
64th atf	atf	5 15	8	6	4	6	6
6th mab	amph	6 14	6	0	0	0	5
437 arbg	armor	57 7	8	0	0	0	4
194 arbg	armor	37 5	8	0	0	0	4
37 mech	mech	57 7	8	0	0	0	4
87 abn	abn	6 4	4	0	0	0	3

TYPE = Unit type
Location = Hex row and column
Mob = Mobility, Movement points
EWV = EW value, ability of an air wing to overcome enemy air defense by jamming weapon control radar
CASV = Close air support capability of air wing
CAV = Counter air value of air wing
ADNO = Air defense value of ground unit

Attachment A-5

INITIAL DEFAULT EQUIPMENT LISTS FOR ACQUISITION PHASE

RED EQUIPMENT			GREEN EQUIPMENT		
End Item	System	Number	End Item	System	Number
artac 1	1	1	artac 1	1	4
navtac 1	3	2	hftty 1	7	6
aftac 1	5	2			
wbs 1	9	2			
sat 1	16	1			
gt-sat 1	17	2			

Attachment A-6

DEFAULT EQUIPMENT FOR OPERATIONS PHASE

RED EQUIPMENT

End Item	System	Number
artac 1	1	1
artac 2	2	4
navtac 1	3	3
aftac 1	5	2
hftty 2	8	12
wbs 1	9	6
shf-sat	11	1
shf-gt	12	3
vlf	13	1
tritac	14	1
sat 1	16	1
gt-sat 1	17	3
singars	22	1
singargt	23	3
abncp 1	24	3
awacs	26	1
awacs-eh	27	2
spysat 2	29	2
atksat 1	30	3
ew 1	32	3
ew 3a	35	1
ew 5a	38	1

GREEN EQUIPMENT

End Item	System	Number
artac 1	1	4
artac 2	2	1
navtac 2	4	3
aftac 2	6	2
hftty 1	7	12
wbs 2	10	6
shf-gt	12	6
vlf	13	1
tritaceh	15	1
sat 3	20	1
gt-sat 3	21	3
abncp 2	25	2
awacs	26	4
spysat 1	28	2
atksat 1	30	1
atksat 2	31	2
ew 2	33	5
ew 3	34	1
ew 4a	37	1

Attachment A-7

CINCRED CONPLAN 4123 (U) [Ref. 1]
PLAN SUMMARY (U)

1. PURPOSE: This CONPLAN fulfills a task assignment in the Joint Strategic Capabilities Plan (JSCP). The purpose to be achieved by executing this plan is to ensure a continued supply of critical resource X for Country RED. This will be accomplished by employing a Joint Task Force (JTF) to seize and occupy the Southern Mines in UTOPIA and the Port of Utopia.

2. CONDITIONS OF EXECUTION: UTOPIA remains a neutral country with no regular military forces of its own. UTOPIA also refuses to have any military forces of other countries stationed on its soil. Our violation of UTOPIA's neutrality must take place only as a last resort. Therefore, execution of this plan will be considered only if worldwide shortages of critical resource X occur and intelligence sources reveal that invasion of UTOPIA by Country GREEN is imminent.

3. OPERATIONS TO BE CONDUCTED: Rapid response is essential and can best be achieved by maintaining prepositioned combat-ready forces as close to UTOPIA as possible. Consequently, this plan will be carried out by our forces now stationed in Country YELLOW which borders on UTOPIA.

a. Deployment. To preclude a strong reaction from Country GREEN and avoid criticism from the world community, we will not significantly increase our military presence in Country YELLOW. We will, however, insure that the units already stationed there achieve full combat strength. As much as possible, we will upgrade their combat and support capabilities. Additional support to our ground and air forces in Country YELLOW will be provided by a carrier task force including marine amphibious forces. This task force will be dispatched to the Gulf of Utopia prior to full execution of the plan.

b. Employment. When the carrier task force reaches the Gulf of Utopia, our ground forces in Country YELLOW will initiate the offensive. If Country GREEN attacks first, our ground forces will immediately respond without waiting for the carrier task force. The following pages summarize the preferred course of action. If we take the offensive, we will execute the preferred course of action. However, if Country GREEN attacks first, our course of action will depend on the situation.

PREFERRED PLAN

Armored brigade B and the mechanized infantry brigade will proceed from Fort RED through Yellow Mountain Pass toward the Southern Mines of Utopia. Once this objective is secured, armored brigade B will proceed toward Blue Mountain Pass to intercept advancing enemy units. To minimize the time required to reach the Port of Utopia, armored brigade A from Fort RED will move north and take up a position within the forest to the east of the Port of Utopia. This unit should be in place before any of our forces cross the border into Utopia. When the carrier task force arrives, a marine amphibious brigade will come ashore east of the Port of Utopia. They will assault the port with the support of armored brigade A moving westward from the forest. The first combat element to move into UTOPIA will be the airborne brigade from RED AB. They will be air dropped into a strategic area overlooking Blue Mountain Pass. From this location they will be able to effectively slow down the movement of enemy forces through the pass. They will later be reinforced by armored brigade B moving across to Southern Mines.

ALTERNATE PLAN

Two armored brigades and one mechanized infantry brigade will proceed from Fort RED through YELLOW Mountain Pass toward the Southern Mines of Utopia. Once this objective is secured, armored brigade A will proceed north along the highway toward the Port of Utopia. Armored brigace B will proceed toward Blue Mountain Pass to intercept advancing enemy units. When the carrier task force arrives, a marine amphibious brigade will come ashore east of the Port of Utopia. They will assault the port from the east while armored brigade A moves up from the south. The first comabat element to move into UTOPIA will be the airborne brigade from RED AB. They will be air dropped into a strategic area overlooking Blue Mountain Pass. From this location they will be able to effectively slow down the advance of enemy forces through the pass. They will later be reinforced by armored brigade B moving across from Southern Mines.

The foregoing summary of courses of action provides military decision-makers a brief recapitulation of the major aspects of this plan. It is based on planning factors and estimates available at the time of preparation, and is subject to modification in the context of a specific contingency. The information it contains should be reviewed, and, if necessary, updated before its use in adopting a course of action in a given situation. Each operations and support agency must prepare and maintain a five-year plan for the acquisition of new systems to support this plan. Include budget estimates.

4. TIME TO COMMENCE EFFECTIVE OPERATIONS. Combat units must achieve full combat readiness within the next two years. Internal communications of combat units must be reviewed and updated as necessary. The JTF HQ must be established and communications provided. Acquisition of systems to upgrade, as necessary, should be included in the five year plan. We anticipate military action in UTOPIA in the next two to six years.

5. COMMAND RELATIONSHIPS. The NCA will retain direct control of plan execution and combat operations. Operational chain of command will be from NCA to JCS to JTF HQ to combat units.

6. EXECUTION. Each operations and support agency must prepare and maintain a list of general actions necessary to place the plan into operation. If the plan had to be executed immediately, how could currently available resources best be employed?

Attachment A-8

CINCGREEN CONPLAN 4123 (U) [Ref. 1]
PLAN SUMMARY (U)

1. PURPOSE. This CONPLAN fulfills a task assignment in the Joint Strategic Capabilities Plan (JSCP). The purpose to be achieved by executing this plan is to ensure a continued supply of critical resource X for Country GREEN. This will be accomplished by employing a Joint Task Force (JTF) to seize and occupy the Southern Mines in UTOPIA and the Port of Utopia.

2. CONDITIONS OF EXECUTION. UTOPIA remains a neutral country with no regular military forces of it's own. UTOPIA also refuses to have any military forces of other countries stationed on it's soil. Our violation of UTOPIA's neutrality must take place only as a last resort. Therefore, execution of this plan will be considered only if worldwide shortages of critical resource X occur and intelligence sources reveal that invasion of UTOPIA by Country RED is imminent.

3. OPERATIONS TO BE CONDUCTED. Rapid response is essential and can best be achieved by maintaining prepositioned, combat-ready forces as close to UTOPIA as possible. Consequently, this plan will be carried out by our forces now stationed in Country BLUE which borders on UTOPIA.

a. Deployment. To preclude a strong reaction from Country RED and avoid criticism from the world community, we will not significantly increase our military presence in Country BLUE. We will, however, insure that the units already stationed there (two armored brigades, one mechanized infantry brigade, one airborne brigade, and two tactical flying units) achieve full combat strength. As much as possible, we will upgrade their combat and combat support capabilities. Additional support to our ground and air forces in Country BLUE will be provided by a carrier task force including Marine amphibious forces. This task force will be dispatched to the Gulf of UTOPIA prior to full execution of the plan.

b. Employment. When the carrier task force reaches the Gulf of Utopia, our ground forces in Country BLUE will initiate the offensive. If Country RED attacks first, our ground forces will immediately respond without waiting for the carrier task force. The following pages summarize the preferred course of action followed by two alternative courses of action. If we take the offensive, we will execute the preferred course of action. However, if Country RED attacks first, our course of action will depend on the situation.

PREFERRED PLAN

Two armored brigades and one mechanized infantry brigade will proceed from Fort Green through the Blue Mountain Pass toward the Southern Mines in UTOPIA. Once this objective is secured, one armored brigade will proceed north along the highway toward the Port of Utopia. The other armored brigade will proceed toward Yellow Mountain Pass to intercept advancing enemy units. When the carrier task force arrives, a marine amphibious brigade will come ashore west of the Port of Utopia. They will assault the port from the west while the armored brigade moves up from the south. The first combat element to move into UTOPIA will be the airborne brigade from Green AB. They will be air dropped into a strategic area overlooking Yellow Mountain Pass. From this location they will be able to effectively slow down the advance of enemy forces through the pass. They will later be reinforced by the armored brigade moving across from Southern Mines.

ALTERNATE PLAN

One armored brigade and one infantry brigade will proceed from Fort Green through Blue Mountain Pass toward the Southern Mines in UTOPIA. Once this objective is secured, the armored brigade will proceed toward Yellow Mountain Pass to intercept advancing enemy units. To minimize the time required to reach the Port of Utopia, one armored brigade from Fort Green will move north and take up a postion within the forest to the west of the Port of Utopia. This unit should be in place before any of our forces cross the border into UTOPIA. They will assault the port with the support of the armored brigade moving eastward from the forest. The first combat element to move into UTOPIA will be the airborne brigade from Green AB. They will be air dropped into a strategic area overlooking Yellow Mountain Pass. From this location they will be able to effectively slow down the movement of enemy forces through the pass. They will later be reinforced by the armored brigade moving across from Southern Mines.

The foregoing summary of courses of action provides military decision-makers a brief recapitulation of the major aspects of this plan. It is based on planning factors and estimates available at the time of preparation, and is subject to modification in the context of a specific contingency. The information it contains should be reviewed, and, if necessary, updated before its use in adopting a course of action in a given situation. Each operations and support agency must prepare and maintain a five-year plan for the aquisition of new systems to support this plan. Include budget estimates.

4. TIME TO COMMENCE EFFECTIVE OPERATIONS. Combat units must achieve full combat readiness within the next two years. Internal communications of combat units must be reviewed and updated as necessary. The JTF HQ must be established and communications provided. Acquisition of systems to upgrade, as necessary, should be included in the five-year plan. We anticipate military action within UTOPIA in the next two to six years.

5. COMMAND RELATIONSHIPS. The NCA will retain direct control of plan execution and combat operations. Operational chain of command will be from NCA to JCS to JTF HQ to combat units.

6. EXECUTION. Each operations and support agency must prepare and maintain a list of general actions necessary to place the plan into operation. If the plan had to be executed immediately, how could currently available resources best be employed?

Attachment A-9

Commanders's Planning Guidance - JTF RED [Ref. 1]

1. The current JSCP tasks us to be prepared to invade the Country of UTOPIA in order to secure a continuing supply of critical resource X. UTOPIA is the richest known source of this resource. Heavy reliance on foreign imports of resource X is expected to continue and worldwide shortages are predicted within five years. Our strongest ideological adversary, Country Green, is also heavily dependent on imports of resource X. Intelligence sources reveal that GREEN is also planning for possible military action in UTOPIA. Our mission is to gain control of UTOPIA's Southern Mines and the Port of Utopia.

2. Type of Operation. This will be a coordinated attack involving a main armored assault with supporting attacks by airborne and amphibious forces. A carrier task force will be postioned in the Gulf of Utopia to support the amphibious forces and defend against enemy naval attack. Country YELLOW which borders on UTOPIA has long been our ally. We have one army base and two tactical air bases in YELLOW that are near the UTOPIA border. We will utilize forces currently stationed in YELLOW for the initial assult.

Country BLUE which also borders on UTOPIA is expected to remain friendly to Country GREEN.

3. Phasing Instructions. Pre-execution preparations that have priority are:

a. Establish a JTF HQ. J6, plan communications to connect the JTF HQ with the NCA, Fort RED, RED AB, and RED AB North. Also, it is essential that deployed combat units have reliable communications with the JTF HQ. Request your recommemdation for the location of the JTF HQ within Country YELLOW.

b. Achieve combat capability as soon as possible. We must be able to support execution in two years. However, we must also plan for continued support of our forces. Insure that your planning covers the next five years and includes both equipment acquisitions and budget estimates.

4. Tentative Courses of Action if CONPLAN is Executed. J3 has provided the following courses of action for accomplishing the mission. Review these in conjunction with the map provided by J2:

a. Course of action #1. Main attack - Ground assault through YELLOW Mountain Pass by two armored brigades and one mechanized infantry brigade. Initial objective will be to seize and occupy Southern Mines. One armored brigade will then proceed north along the highway to the Port of Utopia

and one armored brigade will proceed to BLUE Mountain Pass. Supporting attacks - Amphibious assault on northern coast of UTOPIA by one marine amphibious brigade. Their objective is to seize and occupy the Port of Utopia in conjunction with the armored brigade moving up from Southern Mines. Simultaneous airborne assault on BLUE Mountain Pass by one airborne brigade. Their objective will be to delay enemy advance through BLUE Mountain Pass until armored brigade arrives from Southern Mines.

b. Course of action #2. Main attack - Ground assault through YELLOW Mountain Pass by one armored brigade and one mechanized infantry brigade. Their objective will be to seize and occupy Southern Mines. The armored brigade will then proceed to BLUE Mountain Pass. Supporting attacks - To minimize the time required to reach the Port of Utopia, one armored brigade from Fort RED will move north and take up a position within the forest to the west of the Port of Utopia. When the attack begins, the brigade will cross the border into UTOPIA and join a marine amphibious brigade for a combined assault on the port. Simultaneous airborne assault on BLUE Mountain Pass by one airborne brigade. Their objective will be to delay enemy advance through BLUE Mountain Pass until armored brigade arrives from Southern Mines.

5. Analysis of Relative Combat Power. According to latest intelligence, Country GREEN has the following forces tasked for operations in UTOPIA:

3 armored/mechanized brigades
1 airborne brigade
1 amphibious ready group
1 marine amphibious brigade
1 carrier task force
2 tactical fighter wings
1 JTF HQ
1 tactical air control system

The capability of enemy forces is presently comparable to our own. However, enemy plans for invasion of UTOPIA are unknown as are enemy plans for upgrading their joint task force.

6. NBC Warfare. We will not use nuclear, biological, or chemical weapons. Because we do not know enemy intentions, our forces must remain properly equipped and thoroughly trained for NBC defense.

7. Restrictions on Operations.

a. Close control by the NCA is necessary because of the danger of rapid escalation. Again, rapid and reliable communications are essential between the NCA and the JTF HQ.

b. Because of political considerations, we will not launch any strikes against forces located within the geographic boundaries of Country BLUE.

8. Pertinent Assumptions.

a. It is estimated that military action to ensure a continued supply of critical resource X will be necessary between two and six years in the future with six years being the more likely.

b. Country YELLOW will remain our ally and continue to allow us to maintain combat forces there.

c. Country BLUE will remain an ally of GREEN and GREEN will employ forces stationed in BLUE to support their operations in UTOPIA.

9. Essential Elements of Information.

a. General:

(1) Determine if and when the enemy is planning to invade the Country of Utopia.

(2) Determine if the enemy plans to employ NBC weapons.

b. J1, Personnel

(1) The attitude of the civilian populace within the area of operations.

(2) The amount of food and medical supplies available in the area of operations for distribution to the civilian populace when we secure the area.

c. J3, Operations

(1) Detailed up-to-date enemy order of battle.

(2) Location of enemy JTF HQ.

d. J4, Logistics

(1) Cross-country trafficability studies for wheeled and tracked vehicles.

(2) Location of indigenous POL facilities in area of operations.

e. J6, Communications-Electronics

(1) Availability and nature of enemy electronic jamming capability.

(2) Enemy satellite surveillance capability which can detect the movement of our forces.

10. Request that each directorate prepare their staff estimate. Include your determination of which proposed course of action can best be supported from your standpoint. J6, also include your recommendation for the location of the JTF HQ.

Attachment A-10

Commander's Planning Guidance - JTF GREEN [Ref. 1]

1. The current JSCP tasks us to be prepared to invade the Country of UTOPIA in order to secure a continuing supply of critical resource X. UTOPIA is the richest known source of this resource. Heavy reliance on foreign imports of resource X is expected to continue and worldwide shortages are predicted withing five years. Our strongest ideological adversary, Country RED, is also heavily dependent on imports of resource X. Intelligence sources reveal that RED is also planning for possible military action in UTOPIA. Our mission is to gain control of UTOPIA'S Southern Mines and the Port of Utopia.

2. Type of Operation. This will be a coordinated attack involving a main armored assault with supporting attacks by airborne and amphibious forces. A carrier task force will be positioned in the Gulf of Utopia to support the amphibious forces and defend against enemy naval attack. Country BLUE which borders on UTOPIA has long been our ally. We have one army base and two tactical air bases in BLUE that are near the UTOPIA border. We will utilize forces currently stationed in BLUE for the initial assault.

Country YELLOW which also borders on UTOPIA is expected to remain friendly to Country RED.

3. Phasing Instructions. Pre-execution preparations that have priority are:

a. Establish a JTF HQ. J6, plan communications to connect the JTF HQ with the NCA, Fort Green, Green AB, and Green AB North. Also, it is essential that deployed combat units have reliable communications with the JTF HQ. Request your recommendation for the location of the JTF HQ withing Country BLUE.

b. Achieve combat capability as soon as possible. We must be able to support execution in two years. However, we must also plan for continued upgrade of our forces. Insure that your planning covers the next five years and includes both equipment acquisitions and budget estimates.

4. Tentative Courses of Action if CONPLAN is Executed. J3 has provided the following courses of action for accomplishing the mission. Review these in conjunction with the map provided by J2.

a. Course of action #1. Main attack - Ground assault through Blue Mountain Pass by two armored brigades and one mechanized infantry brigade. Initial objective will be to seize and occupy Southern Mines. One armored brigade will then proceed north along the highway to the Port of Utopia

and one armored brigade will proceed to Yellow Mountain Pass. Supporting attacks - Amphibious assault on northern coast of UTOPIA by one marine amphibious brigade. Their objective is to seize and occupy the Port of Utopia in conjunction with the armored brigade moving up from Southern Mines. Simultaneous airborne assault on Yellow Mountain Pass by one airborne brigade. Their objective will be to delay enemy advance through Yellow Mountain Pass until armored brigade arrives from Southern Mines.

b. Course of action #2. Main attack - Ground assault through Blue Mountain Pass by one armored brigade and one mechanized infantry brigade. Their objective will be to seize and occupy Southern Mines. The armored brigade will then proceed to Yellow Mountain Pass. Supporting attacks - To minimize the time required to reach the Port of Utopia, one armored brigade from Fort Green will move north and take up a position within the forest to the west of the Port of Utopia. When the attack begins, the brigade will cross the border into UTOPIA and join a marine amphibious brigade for a combined assault on the port. Simultaneous airborne assault on Yellow Mountain Pass by one airborne brigade. Their objective will be to delay enemy advance through Yellow Mountain Pass until armored brigade arrives from Southern Mines.

5. Analysis of Relative Combat Power. According to latest intelligence, Country RED has the following forces tasked for operations in UTOPIA:

3 armored/mechanized brigades
1 airborne brigade
1 amphibious ready group
1 marine amphibious brigade
1 carrier task force
2 tactical fighter wings
1 JTF HQ
1 tactical air control system

The capability of enemy forces is presently comparable to our own. However, enemy plans for invasion of UTOPIA are unknown as are enemy plans for upgrading their joint task force.

6. NBC Warfare. We will not use nuclear, biological, or chemical weapons. Because we do not know enemy intentions, our forces must remain properly equipped and throughly trained for NBC defense.

7. Restrictions on Operations.

a. Close control by the NCA is necessary because of the danger of rapid escalation. Again, rapid and reliable communications are essential between the NCA and the JTF HQ.

b. Because of political considerations, we will not launch any strikes against forces located within the geographic boundaries of Country Yellow.

8. Pertinent Assumptions.

a. It is estimated that military action to ensure a continued supply of critical resource X will be necessary between two and six years in the future with six years being the more likely.

b. Country BLUE will remain our ally and continue to allow us to maintain combat forces there.

c. Country YELLOW will remain an ally of RED and RED will employ forces stationed in YELLOW to support their operations in UTOPIA.

9. Essential Elements of Information.

a. General:

(1) Determine if and when the enemy is planning to invade the Country of UTOPIA.

(2) Determine if the enemy plans to employ NBC weapons.

b. J1, Personnel

(1) The attitude of the civilian populace within the area of operations.

(2) The amount of food and medical supplies available in the area of operations for distribution to the civilian populace when we secure the area.

c. J3, Operations

(1) Detailed up-to-date enemy order of battle.

(2) Location of enemy JTF HQ.

d. J4, Logistics

(1) Cross-country trafficability studies for wheeled and tracked vehicles.

(2) Location of indigenous POL facilities in area of operations.

e. J6, Communications-Electronics

(1) Availability and nature of enemy electronic jamming capability.

(2) Enemy satellite survelIance capability which can detect the movement of our forces.

10. Request that each directorate prepare their staff estimate. Include your determination of which proposed course of action can best be supported from your standpoint. J6, also include your recommendation for the location of the JTF HQ.

COMBAT OUTCOME TABLE

Random Numbers

POINT DIFFERENCE	1	2	3	4	5	6	7	8	9	10
-5	1 0 0 2 0 0	1 0 0 2 0 0	2 0 0 2 0 0	2 0 0 2 0 0	2 0 0 1 0 0	2 0 0 0 0 0	1 1 1 0 0 0	2 1 1 0 0 0	2 2 2 0 0 0	9 9 9 0 0 0
-4	1 0 0 3 1 0	1 0 0 3 0 0	2 0 0 1 2 0	2 0 0 1 1 0	2 0 0 1 0 0	2 0 0 1 0 0	2 1 0 1 0 0	1 1 1 0 0 0	2 1 2 0 0 0	3 2 2 0 0 0
-3	1 0 0 2 2 1	1 0 0 2 1 0	1 1 0 1 0 1	1 1 0 2 0 0	2 0 0 1 0 0	1 1 0 1 0 0	2 1 0 1 0 0	3 1 0 1 0 0	3 1 1 1 0 0	3 2 1 0 0 0
-2	1 0 0 2 2 1	0 1 0 3 0 1	1 0 0 1 1 1	1 0 0 1 0 1	1 1 0 1 0 0	0 1 0 1 0 0	2 1 0 0 1 0	2 1 0 0 1 0	3 1 0 1 0 0	3 1 1 1 0 0
-1	0 1 0 3 1 1	1 0 0 3 1 1	2 0 0 3 1 0	2 0 0 2 1 0	1 0 0 1 0 0	0 0 0 0 0 0	2 0 0 1 0 0	2 1 0 1 0 0	2 1 0 0 0 0	2 1 1 0 0 0
0	1 0 0 3 1 2	1 0 0 3 2 1	2 0 0 2 1 1	1 0 0 2 0 1	2 0 0 2 0 0	1 0 0 1 0 0	0 0 0 0 0 0	1 0 0 0 0 0	2 0 0 0 0 0	1 1 1 0 0 0
1	1 0 0 3 2 1	0 1 0 3 2 1	1 0 0 2 1 1	2 0 0 2 1 1	1 0 0 0 1 0	2 0 0 2 0 0	1 0 0 1 0 0	0 0 0 0 0 0	1 0 0 0 0 0	2 1 0 1 0 0
2	1 0 0 2 2 2	1 0 0 3 2 1	1 0 0 3 1 1	1 0 0 2 2 1	1 0 0 1 1 0	1 0 0 0 1 0	2 0 0 0 1 0	1 1 0 0 1 0	1 0 0 1 0 0	1 0 1 1 0 0
3	0 0 0 4 2 2	0 0 0 2 2 2	1 0 0 3 2 1	1 0 0 3 2 1	1 0 0 1 1 1	1 0 0 1 0 1	1 0 0 0 0 1	1 0 0 0 1 0	2 0 0 0 1 0	2 0 0 0 1 0
4	0 0 0 9 9 9	0 0 0 3 2 2	0 0 0 3 2 2	0 0 0 2 2 2	0 0 0 1 2 1	1 0 0 0 1 1	1 0 0 0 1 1	1 0 0 0 0 1	1 0 0 0 0 1	2 0 0 0 1 0

APPENDIX B

COMEL MAINTENANCE MANUAL

FIGURES

• 1. INTRODUCTION

The purpose of this manual is to document the software used in Communications Electronics War (COMEL) so that it can be modified easily. The program was written using modular design, frequent comments, and structured FORTRAN in an attempt to write code that could be read, understood, and modified by novice programmers. Further information can be found in the Users' Manual and the Thesis.

This manual is divided into four major sections to describe machine dependency, the main and control programs, the Acquisition Phase, and the Operations Phase.

2. HARDWARE/SOFTWARE DEPENDENCY

This section describes the characteristics of the program that make COMEL dependent on the specific computer and operating system for which it was designed.

COMEL was developed on a Digital Equipment Corporation VAX 11/780. The operating system used is VMS. (VAX stands for Virtual Address Extension and VMS stands for Virtual Memory System.) COMEL can be run on any other system that supports FORTRAN-77 and has some type of command file executive. Any type of terminal can be used to play COMEL.

Throughout the program, but primarily in the Operations Phase, random numbers are used. The VAX/VMS system function RAN (which calls the subroutine RANDOM) is used to generate the pseudo-random numbers. The function updates the seed, which is carried from module to module as a common variable.

FORTRAN 77 structures, such as the DO WHILE and the IF-THEN-ELSE-IF are used extensively, as is variable type character which allows easy structuring of the program and enhances its maintainability and readability. To modify the game to run on another verson of software, which does not have these features, would require a line-by-line review of the code to locate and modify these structures. The system functions FLOAT, IFIX, ATAN, and MIN are used but are also

availible on most FORTRAN compilers. The only other system unique function used in the actual COMEL FORTRAN modules is the time routine SECNDS (defined by the system as time in seconds since midnight).

COMEL can be run two ways. There is an extended version that runs via a control language (VAX/VMS command language). The other version is the same game run without the control language extension. The only difference between the two versions is that the extended COMEL takes care of game file preparation, modification, and exercise data saving (This process is explained in the Users' Manual and in Section 3.4 of this manual). This method was selected despite the machine dependency, since the efficiency of doing the file manipulation at the command level of the computer far exceeded the writing of the equivalent code in FORTRAN (ie, about a 500 line command language program instead of a 2000+ line FORTRAN program).

While not a machine dependency, one technique used to control the synchronization of the Umpire, Red, and Green terminals used in this war game, should be explained in this section. An important part of COMEL involves the timing of actions to be taken by the different players in the game. The Red or Green Player can only take actions during a specified part of the game (ie, for a given turn only so many minutes are allotted). When this time has expired, the player must wait until the Umpire (or control program) has

accomplished some tasks (budget planning, war execution, etc). Some control information also has to be passed to the players by the Umpire (current game status, war status, end of game commands, etc). This is done through a synchronization routine.

The synchronization is accomplished via a common direct access file. Three flags control the flow of control, a controller flag (ictl), Red Player flag (ired) and Green Player flag (igrn). These flags are set to zero or one depending on the action to be taken. When the Umpire wants to hold the players , a zero is written to ired and igrn. The players' game will be stopped until the Umpire sets ired and igrn to one. If ictl is equal to 9, the Acquisition or Operation Phase will be stopped. Initially, ictl is equal to one and ired and igrn are set to zero. Red Player sets ired to one and Green Player sets igrn to one when each logs on. In the same way, control is halted at the end of each turn by issuing the appropriate flag.

3. MAIN PROGRAM AND CONTROL MODULES

The control program sets up the files used in COMEL. It is written in the VAX/VMS command file language. The control modules are started by the control program. These control modules are short FORTRAN programs that call the appropriate phase of COMEL.

3.1 PROGRAMMING STYLE

The command file program is written to manipulate the game files. The style of programming is limited to placing the commands in the correct order for execution. The FORTRAN modules called control the execution phase entered in COMEL.

3.2 ERROR CHECKING

The error checking performed is limited to testing for correct menu input and trapping error conditions to prohibit the Umpire or player from being thrown out of the program. Instead, the question will be repeated. The FORTRAN control module will only allow menu selections to be entered.

3.3 STRUCTURE OF THE CONTROL PHASE

The control phase of the program consists of setting up the files, running the program, entering the correct phase, and saving the files on exit from the game.

3.4 CONTROL MODULES (ACQUISITION AND OPERATIONS)

COMEL CONTROL PROGRAM (COMMAND FILE)

File: COMEL.COM

Purpose and Method:

A collection of command language routines used by the Umpire to manipulate the game files (save, restore, delete) and run COMEL.

The main menu of the command file is displayed on the terminal and user input is requested. The action requested is carried out via a GOTO to a command module written to carry out the Delete, Save, or Restore.

Two error routines are provided to prevent the accidental destruction of files. One is to prevent the program from failing due to an error in the command file (ie, copying a non-existant file). The second error protection is to return to the main menu if the Umpire/Player tries to exit COMEL via a CTRL-Y.

Subprograms Called:

UMPIRE.FOR (Main Program)

MAIN PROGRAM UMPIRE

File: UMPIRE.FOR

Purpose and Method:

This is the control program the Umpire uses to choose to play the Acquisition, Operation or both phases of COMEL.

The menu is displayed and, depending on the option selected, control is passed to the called routine. When the program is exited, control is returned to the command program.

Major Variables:

fini - logical; controls exit from this program

Subprograms Called:

Subroutine GAMINF
Subroutine ACQCTL
Subroutine OPNCTL

Entries:

@COMEL

SUBROUTINE PLAYER

File: PLAYER.FOR

Purpose and Method:

This is the control program for the player. The player is identified as Red or Green. The Acquisition, Operation or both phases of play is then selected.

Major Variables:

fini - logical; controls end of program

iredpl - integer; flag indicating a Red Player

igrnpl - integer; flag indicating a Green Player

Subprograms Called:

Subroutine PLYINF
Subroutine PAGE
Subroutine REDACQ/GRNACQ
Subroutine REDOPS/GRNOPS

Entries:

@PLAYER

SUBROUTINE ACQCTL

File: ACQCTL.FOR

Purpose and Method:

This module provides timing and sequencing for the Acquisition Phase of the game.

Output Acquisition game header to the Umpire and call input routine for system data. The Umpire enters the length of coming turn and then is provided the budget history. Set synchronization file to wait for Red and Green Player. Update stop time and then let Red and Green Players start turn. Loop through a delay routine until both players are done or until time runs out. The players then enter a waiting stage. The Umpire enters the intelligence update phase. The next turn starts unless war begins in which case the Acquisition Phase ends.

Major Variables:

durmin - real; time in minutes of current turn

ictl,igrn,ired - integer; action completion flags

hhmmss - character * 8; time of day

s,it,r,q - real; dummy variables

pwar - real; the current probablity that war will occur

x - real: contains the result of random variable function

Common Variables Changed:

iplayr
iseed
stopat

Subprograms Called:

Subroutine SYSEQP
Subroutine BGTHST
Subroutine WRITIT
Subroutine DELAY
Subroutine PAGE
Subroutine TIME
Subroutine READIT
Subroutine TATTLE

Entries:

Main Program UMPIRE.FOR

SUBROUTINE PAGE

File: PAGE.FOR

Purpose and Method:

This routine clears the terminal display by writing 24 blank lines.

Entries:

General Utility

SUBROUTINE READIT

File: READIT.FOR

Purpose and Method:

This routine opens and reads the synchronization file necessary for control of the game. The budget and turn is passed to the players.

Parameters passed:

ictl	igrn	ired	stopat
iturn	redbgt	grnbgt	

Subprograms Called:

Subroutine DELAY

Data Files Accessed and File Name:

50 - Synchronization File SYNCH.DAT

Entries:

General Utility

SUBROUTINE WRITIT

File: WRITIT.FOR

Purpose and Method:

This routine opens and writes to the synchronization file items necessary for control of the game.

Parameters Passed:

ictl	igrn	ired	stopat
iturn	redbgt	grnbgt	

Subprogram Called:

Subroutine DELAY

Data Files Accessed and File Name:

50 - Synchronization File SYNCH.DAT

Entries:

General Utility

SUBROUTINE DELAY

File: DELAY.FOR

Purpose and Method:

This routine is used whenever a delay in execution is desired. The delay is the parameter passed, in seconds, to the program.

Parameters passed:

t1 - real; time delay routine entered

Major Variables:

delta - real; The difference between time entered delay and current time.

a - real; A variable entered just to delay.

Entries:

General Utility

SUBROUTINE OPNCTL ()

File: UMPFILE.FOR

Purpose and Method:

This module provides timing and sequencing for the Operations Phase of the game.

Output Operations game header. Check whether starting a new game; get seed and call input subroutine or read blackboards. Display unit positions to set up map. Loop through turns. Input turn length and rules of engagement. If it is not the first turn, output intelligence. Output blackboards. Wait for players to finish turn, checking periodically for messages or end of

time limit. When time is up or both players are finished, continue with movement, combat, and end of war decision.

Major Variables:

hhmmss - character*8; time

first - integer; rules of engagement

ictl,igrn,ired,it,ishr,ismn - integers; action completion flags

durmin - real; length of turn in minutes

dummy,s,stemp - real; dummy variables

stopat - real; scheduled end of turn

over - logical; true if game is to end

Subprograms Called:

Subroutine PAGE	Subroutine RULES
Subroutine DELAY	Subroutine OPINTEL
Subroutine TIME	Subroutine INPUT
Subroutine WRITIT	Subroutine RPOSIT/GPOSIT
Subroutine READIT	Subroutine RMOVE/GMOVE
Subroutine RMSG/GMSG	Subroutine DICTION
Subroutine SYSOUT	Subroutine COMBAT
Subroutine SYSBRD	Subroutine ENDWAR
Subroutine REDOUT/GRNOUT	Subroutine REDBRD/GRNBRD

Entries:

Main program UMPIRE.FOR

SUBROUTINE REDOPS/GRNOPS ()

File: RED.FOR/GREEN.FOR

Purpose and Method:

This module controls the timing and sequence of the routines for the Red or Green Player.

Output Operations Phase header. Wait until start is indicated by Umpire, checking periodically for messages. On the first turn call module to assign equipment to units. Call turn module; return to waiting.

Major Variables:

ictl, ic, ired,igrn - integers; control flags

stopat - real;time for scheduled end of turn

dummy,st - real; dummy variables

hhmmss - real;present time

Subprograms Called:

Subroutine PAGE	Subroutine RMSG/GMSG
Subroutine TIME	Subroutine RCOMM1/GCOMM1
Subroutine READIT	Subroutine RTURN/GTURN
Subroutine WRITIT	Subroutine DELAY

Entries:

Main program PLAYER.FOR

<u>SUBROUTINE RLISTEN/GLISTEN</u> (QUEST,ANS)

File: GENERAL.FOR

Purpose and Method:

This module allows an active terminal to listen for and read the answer to a message previously sent to another terminal. The exchange of messages is between the Umpire and a player.

Parameters:

quest - integer; flag indicating whether answer is expected to the question

ans - character*1; answer, blank returned if no answer is expected

Subprograms Called:

Subroutine DELAY

Entries:

General Utility

SUBROUTINE RMSG/GMSG ()

File: GENERAL.FOR

Purpose and Method:

This module allows a terminal in waiting status to receive and answer messages from another terminal. The exchange of messages is between a player and the Umpire.

Major Variables:

flag - integer; flag showing an answer is expected

record - character*80; text of message

ans - character*1; answer

Subprograms Called:

Subroutine DELAY
Subroutine PAGE

Entries:

Subroutine OPNCTL
Subroutine REDOPS/GRNOPS

SUBROUTINE OPEN (NUM)

File: GENERAL.FOR

Purpose and Method:

This module opens file 'num', making an error check to see if the file is empty.

Parameter:

num - integer- number of the device to be opened

Entries:

General Utility

iturn nbrsys system etype

Subprograms Called:

Subroutine PAGE

Entries:

Subroutine PROCUR

SUBROUTINE MDEPLY

File: MDEPLY.FOR

Purpose and Method:

The Red/Green Player can place a system in manufacturing for deployment.

First, go through the equipment array to determine systems available for M+D and save the pointers in an array. Then, display all available for M+D on the player's terminal. This is done via the index saved earlier and a format routine to place the data on the terminal. The Red/Green Player enters the selection. The program then asks for another system.

Major Variables:

fini - logical; controls end of program

nmnd - integer; number of systems available for M+D

ndex(200) - integer; pointer to the systems available for M+D

itmnbr - integer; selected system reference

idectm - integer; decision time left

pge - real; used to align display

npage - integer; used to align display

i1,i2,i3,i4 integer; used to align display

iyr1,iyr2,iyr3,iyr4 - integer; holds year for display

Common Variables Changed:

gbgusd	rbgusd	gyrbgt	ryrbgt
gyrrdy	ryrrdy	igbuy	irbuy
igacc	iracc	igexp	irexp
igred	irred	igmnfd	irmnfd
gsystm	rsystm		

Common Variables Referenced but Not Changed:

stopat	nbreqp	iplayr	iturn
rdtime	gitem	ritem	gsystm
rsystm	grnbgt	redbgt	mdtime
mdcost			

Subprograms Called:

Subroutine PAGE

Entries:

Subroutine PROCUR

5. THE OPERATIONS PHASE

5.1 PROGRAMMING STYLE

As much as oossible, the Operations Phase is written in structured FORTRAN in a very simple style so that it can be modified by novice programmers. Modules are small, with frequent comments as to their purpose, and with extensive use of subroutines and functions. Only four basic structures are used:

a. The DO WHILE

```
      DO WHILE (XXX)
          .
          .
      END DO
```

b. The DO UNTIL

```
   10 CONTINUE
          .
          .
      IF (XXX) GO TO 10
```

c. The DO FOR

```
      DO 10 I=M,N
          .
          .
   10 CONTINUE
```

d. The IF-THEN-ELSE-IF

```
      IF (XXX) THEN
          .
          .
      ELSE IF (XXX) THEN
          .
          .
      END IF
```

Sentinals are used extensively. The system, equipment, unit, and key objective data files all end with a '-1' as a sentinal. Most modules use at least one loop that searches a list until the sentinal is found.

The primary exceptions to structured FORTRAN are in the control modules described in Section 3 and in the error checking described in Section 5.2.

5.2 ERROR CHECKING

There are four types of error checks used in the Operations Phase. When reading from the terminal, if the system detects an error, such as a letter when a number is expected, a return to the same question will result. The sequence would look like this:

```
 10 WRITE (6,1000) QUESTION
    READ (5,2000,ERR=10) ANSWER
```

When reading from a file, an end of file marker will cause an escape from the loop. For example:

```
    i = 1
    DO WHILE (redunt(i) .ne. '-1')
       READ (16,1000,ERR=10) rrow(i),rcol(i)
         .
         .
         .
       i = i + 1
    END DO
10  CONTINUE
```

The third type of error check is a check of the logic of an answer. This type of check uses structures inside the module itself. For example, the input name of a unit to be airlifted is checked against the list of units to make sure

it is a valid name; then the unit type (rforce or aforce) is checked to see if the unit is airmobile. If it is not a valid unit name, an error message appears and the program either askes for a new name or returns to a menu selection. In some cases where it repeatedly asks for a new name, the program will accept the word 'stop' as a signal to return to a menu.

The fourth error check is a logical check of hex coordinates. Any time hex coordinates are entered at the terminal, Subroutine CHECK is called to verify them. It checks to make sure the numbers are not larger than the map and that they are both odd or both even. If they are not valid coordinates, the subroutine types an error message and asks for new coordinates until it gets valid ones.

5.3 STRUCTURE OF THE OPERATIONS PHASE

5.3.1 Game Sequence

The two players and the Umpire are operating in a timed sequence controlled by the modules described in Section 3. The main portion of the Operations Phase is a large DO WHILE loop that continues until the ENDWAR subroutine sets the logical flag OVER to true. The sequence of the loop is as follows:

a. The Umpire sets the rules of engagement.

b. In turn 1, the players assign electronic equipment to units or locations.

c. In turns other than 1, intelligence requested in the last turn is output to the players.

d. The players have a timed turn in which they change movement goals, assign air missions, request intelligence, etc.

e. The Umpire's program moves the units toward their destinations. If conflict situations arise the players are asked whether or not they want to attack or retreat.

f. Any attack requests are referred to the level required by the rules of engagement.

g. If attacks are approved, interdiction, close air support, counter air, and ground combat are conducted.

h. The Umpire is given the opportunity to end the game or repeat the loop for another turn.

The game sequence described above results from a complex heirarchy of modules, described in Section 5.6.

5.3.2 Common Variables

The Operations Phase uses 17 sets of common variables which are referenced and/or changed by the various modules. These variables are of seven main types:

a. Map descriptions
b. Electronic system descriptions
c. Unit descriptions
d. Action request details
e. Frequently used character variables
f. Game control variables

Many of these variables are initially input from data files, others by particular modules. The variables are defined in

Section 5.5; the module descriptions in Section 5.6 identify the common variables that are referenced and/or changed by each module.

5.3.3 Interfaces

There are two types of interfaces between the players and the Umpire. The first type of interface is by message; the active module can write messages to files 40 (for Red-Umpire messages) or 41 (for Green-Umpire messages). The inactive, waiting terminal periodically checks the files for messages and returns the answer or a dummy answer to the file, to be read by the active terminal. The routines used for this purpose are Subroutines RLISTEN, GLISTEN, RMSG, and GMSG, which are described in Section 3.4.

The second type of interface is via blackboards. When control of the game is passed from the Umpire to the players, the Umpire writes all common variables to files 25 (SYSBRD.DAT), 26 (REDBRD.DAT), and 27 (GRNBRD.DAT) using Subroutines SYSOUT, REDOUT, and GRNOUT. The players then read all three of the blackboards using Subroutines SYSBRD, REDBRD, and GRNBRD. The player's actions can change only the information in the blackboard of the same color, but cannot change either the system blackboard or the other player's blackboard. When they are finished they write only the blackboard of their color, using Subroutines REDOUT or GRNOUT. The Umpire reads all the blackboards and can make changes to any of them.

5.4 MODIFICATION

5.4.1 Modification of the Control Sequences

Modifications of Subroutines OPNCTL, REDOPS, GRNOPS, RLISTEN, GLISTEN, RMSG, and GMSG require more than novice level programming knowledge and should be undertaken accordingly. See Section 3.4 for further information.

5.4.2 Modification of Data Lists

Input data changes can be made easily, but details such as file columns are important. To modify a data file, such as the system list, establish a new file, for example SYSTEM2.DAT, and copy the default file into it. Use the editor to make any desired changes, being sure to keep the column formats and data types unchanged. The new file can be substituted for the default file by the Umpire, merely by selecting Option 5 "MOD GAME: TAILOR DATA FILES" in the "COMEL WAR GAME OPTIONS" menu and giving the filename of the new file (See COMEL CONTROL PROGRAM in Section 3.4).

5.4.3 Single Module Changes

Some changes require only one module to be modified (or one Red module and the mirror image Green module). For instance the terrain effect on communications is moduled in Subroutines RTERAIN and GTERAIN. The effect of terrain on movement is modeled in Real function PNTS.

To make a change to a single module, copy the module to a new file, make the changes, and then compile the file. Copy the original with no changes to a separate file to save it in case you later want to reinsert it. Add your new routine to the executable library file by the following sequence of commands: [Ref. 5]

```
$ LIBRARY/REPLACE WARLIB [C/R]
$ FILE:      filename  [C/R]
```

The filename entered should be that of your new routine. The program must then be relinked with the commands:

```
$LINK UMPIRE,ACQUIS/LIB,WARLIB/LIB [C/R]
$LINK PLAYER,ACQUIS/LIB,WARLIB/LIB [C/R]
```

The executable file of the game will now include the new routine until the LIBRARY/REPLACE and LINK commands are repeated, replacing the original version or inserting still another new version of the same module.

If your new module doesn't work, compile and replace the original version into the executable file in the same way. If your version does work and you want to make the change permanent, include your module in the source file (UMPFILE.FOR, RED.FOR, or GREEN.FOR) ,in place of the original. (The location of each module is listed in the file descriptions in Section 5.6.) Document your change by making the necessary corrections to the User's and Maintenance Manuals.

For example, to change the Subroutine ENEMY, check the module listings in Section 5.6 of this manual to see that ENEMY is in file GENERAL.FOR. Use the editor to create a new file, ENEMY2.FOR. Include GENERAL.FOR in the new file and delete everything except ENEMY. Make the desired changes to Subroutine ENEMY then exit the file and compile the new version. Substitute the new version for the old one in the library with the LIBRARY/REPLACE command, entering the filename ENEMY2 on the second line. Link the program and test it. To replace the original version of ENEMY, compile GENERAL.FOR and replace it in the library and relink. To make the new version of ENEMY permanent, edit GENERAL.FOR, deleting the old version and including the new one in it's place.

5.4.4 New Electronic System Types

To add a new type of electronic system, such as laser communications, satellite jammers, airborne electronic warfare, etc. the easy part is adding the system to the system data file with appropriate system data information. You then must review the input routine, the terrain sequences, the communications effectiveness functions, the player action modules, and the combat sequence modules to see if any changes are needed to implement the new system. If any modules must be changed, modify and insert each change as described in Section 5.4.3, test the changes thoroughly, and revise the documentation.

5.4.5 New Unit Types

To add a new type of unit, such as a light infanty brigade or a ground reconnaissance squadron, add the unit to the data files with appropriate combat, air defense and other values. Then review the input, player action, and combat sequences to see if changes are needed. Implement and document as described earlier.

5.4.6 Revisions of Combat Models

A change to close air support, counter air, interdiction, movement, intelligence, or ground combat modules may involve changing several routines. If you want to change a particular module, check especially its parents in the heirarchy tree by tracing the entries, and its children, by tracing the programs called (listed in each module description). Most player action modules are tied closely to one or more Umpire modules. For example, RRECON and GRECON set variables triggering OPINTEL. Be sure to check both player and Umpire modules for necessary changes. Implement and document your changes as previously described.

5.5 COMMON VARIABLES (OPERATIONS PHASE)

/hex/

hex(66,60) - character*1; for each hex in the map, identifies the terrain as open, woods, mountain, desert, sea, or lake

owner(66,60)- character*1; for each hex, identifies whether presently neutral, or occupied by red, green, or both

lasown(66,60)- character*1; identifies the last side to have been in each hex

/rhex/

rhex(66,60)-integer; 2 for hexes on one bank of a river and 1 for hexes on the other side; 0 for hexes not or bank

vhex(66,60)-integer; 1 for hexes containing road, 0 otherwise

keya(20,2)-integer; row and column of major objectives

keyb(20,2)-integer; row and column of minor objectives

/system/

system(50)-character*8; equipment nomenclature

etype(50)-character*5; classifies each system by type

noa(50)-integer; number of end items of each kind available

rdcost(50)-integer; cost in $M for Research and Development of system

rdtime(50)-integer; time in years required for R+D

ardcst(50)-integer; cost for accelerated R+D

ardtim(50)-integer; time for accelerated R+D

mdcost(50)-integer; cost for manufacturing and deployment

mdtime(50)-integer; time in years for M+D

nomcst(50)-integer; cost of normal operating and maintenance

romcst(50)-integer; cost of O+M at reduced readiness

mob(50)-integer; mobility in hexes per turn

crng(50)-integer; communications range in hexes; beamwidth of satellites

crngs(50)-integer; for HF equipment, skywave range

sec(50)-integer; security factor; ability to resist jamming and intrusion

rel(50)-real; reliability

rels(50)-real; reliability of HF equipment in skywave operation

flex(50)-real; flexibility

opt(50)-real; opt ?????

c3e(50)-real; C3 effectiveness

c3es(50)-real; C3 effectiveness of HF in skywave operation

ewf(50)-integer; Electronic Warfare effectiveness; ability of EW equipment to overcome the security factor of communications equipment

ecm(50)-real; effectiveness of jamming

esm(50)-integer; ability to detect emisions

beams(50)-integer; for satellites, the number of beams

/table/

table(50,50)-character*1; compatibility table; n if not compatible; t if compatible; w if compatible only with wire connection; g if wire connection only in same hex

ncapat(50)-character*1; compatibility of equipment with systems at NCA

/table2/

table2(10,10,6)-integer; combat results table

/redunt//grnunt/

redunt/grnunt(20)-character*8; names of combat units

rforce/gforce(20)-character*5; type of unit

/redpos//grnpos/

rrow/grow(20)-integer; row location of unit

rcol/gcol(20)-integer; column location of unit

rumob/gumob(20)-integer; mobility of unit

rgoal/ggoal(20,2)-integer; destination of unit

rcmbtp/gcmbtp(20)-real; combat points of unit

radno/gadno(20)-integer; air defense value of unit

rcasv/gcasv(20)-integer; close air support value of air wing

rcav/gcav(20)-integer; counter air value of air wing

rewv/gewv(20)-integer; ability of air wing to use jammers and other tactics to overcome enemy air defenses

rcnlst/gcnlst(20)-integer; identifies intentions of unit in enemy control zone; 4 if unit was last to arrive and wishes to attack; 3 if unit was first to arrive and wishes to attack; 2 if unit is defensive only

rseal/gseal(10,2)-integer; sealift information; task force and marine indexes in unit list

rown/gown(10,3)-integer; list of changes to owner matrix; row, col, and value of hex

rlas/glas(10)-integer; corresponding value of lasown hex

/redeq//grneq/

redeq/grneq(100)-character*8; nomenclature of equipment

raunit/gaunit(100)-character*8; mobile equipment unit assignment

rmode/gmode(100)-character*5; ESM or ECM mode of operation for EW equipment

/reqpos/geqpos/

reqrow/geqrow(100)-integer; row location of equipment

reqcol/geqcol(100)-integer; column location of equipment

ritem/gitem(100)-integer; system number of equipment; link to system list using the index number in that list

rtc3e/gtc3e(100)-real; temporary C3 effectiveness, based on basic c3e value, terrain and jamming effects

rtc3es/gtc3es(100)-real; temporary C3E of HF in skywave ops

rtcrng/gtcrng(100)-integer; temporary range, after terrain effects

rbeam/gbeam(100,10,2)-integer; center of satellite beams

rrom/grom(100)-real; percentage of normal effectiveness due to reduced readiness (because of cost cutting in Acquisition Phase of game)

/redwar//grnwar/

rintd/gintd(20,5,2)-integer; target locations for interdiction

rtintd/gtintd(20)-integer number of interdiction missions possible in this turn by this air wing

rtcasv/gtcasv(20)-integer; temporary close-air-support value of an air unit; based on normal value, comm effectiveness and jamming

rtcav/gtcav(20)-integer; temporary counter-air value

rrecce/grecce-integer; number of reconnaisance missions requested

rpathr/gpathr(20,50)-integer; row values of projected path to goal; for air wings, route of recce photo run

rpathc/gpathc(20,50)-integer; column values of path

rstart/gstart(20)-integer; next hex in path

rend/gend(20)-integer; last hex in path

rlenth/glenth(20)-integer; length of path in movement points

rab/gab-integer; index number of airborne command posts

rabl/gabl(10)-integer; list of index numbers of all ABNCP

raba/gaba-integer; ABNCP presently on call

ricol/gicol(100)-integer; left hand column for intelligence satellite to survey

raw/gaw-integer; lindex number of AWACS

rawl/gawl(10)-integer; list of index numbers of all AWACS

rawa/gawa-integer; AWACS presently on call

ravalb/gavalb-real; probability of ABNCP being operational; based on number purchased

ravalw/gavalw-real; probability of AWACS being available

rlift/glift-integer; index number of unit being airlifted

rdrop/gdrop(2)-integer; location of drop zone

rland/gland-integer; index number of unit being debarked from sealift

rshore/gshore(2)-integer; location of landing

rtargt/gtargt-integer; index number of satellite being targeted

rweapn/gweapn-integer; index number of anti-satellite weapon

/words/

jtfhq - character*5; JTFHQ

armor - character*5; armored brigade

relay - character*5; communications relay or EW detachment

mech - character*5; mechanized brigade

cbg - character*5; carrier battle group

atf - cqaracter*5; amphibious task force

abn - character*5; airborne brigade

tfw - character*5; tactical fighter wing

amph - character*5; Marine amphibious brigade

air - character*5; type unit used in getting direct path from optimum path routine (not affected by terrain)

gtsat - character*5; satellite ground terminal

abncp - character*5; airborne command post

awacs - character*5; AWACS

ew - character*5; EW iquipment

tac - character*5; tactical equipment

hf - character*5; hf equipment

los - character*5; line-of-sight equipment

sat - character*5; communications satellites

vlf - character*5; vlf equipment

sw - character*5; switching system

spy - character*5; intelligence satellite

asat - character*5; anti-satellite weapon

red - character*1; 'r'; Red Player

grn - character*1; 'g'; Green Player

/game/

gamtrn-integer; number of present operations turn; day number

seed-integer; seed for random number generator

delta-integer; length of turn in seconds

5.6 THE OPERATIONS MODULES

SUBROUTINE INPUT ()

File: UMPFILE.FOR

Purpose and Method:

This routine opens and reads the data files necessary for the Operations Phase.

Open and read files for map data and system information. Read lists of equipment; if file is empty, call Subprogram INITIAL to build new list. Determine whether Umpire wants to build a new unit list; if so call Subroutine UNITLIST; if not, read default list. Open and read combat results table. Open blackboards.

Common Variables Changed:

hex	ardtim	ewf	rcmbtp/gcmptp
rhex	nomcst	ecm	radno/gadno
vhex	romcst	esm	rcasv/gcasv
keya	mob	beams	rcav/gcav
keyb	crng	table	rewv/gewv
system	crngs	ncapat	redeq/grneq
etype	sec	table2	rtc3e/gtc3e
noa	rel	redunt/grnunt	rrom/grom
rdcost	rels	rforce/gforce	ritem/gitem
rdtime	flex	rrow/grow	rseal/gseal
mdcost	opt	rcol/gcol	owner
mdtime	c3e	rumob/gumob	lasown
ardcst	c3es	rgoal/ggoal	gamturn

Subprograms Called:

Subroutine INITIAL
Subroutine UNITLST

Data Files Accessed and File Name:

11 - Hex data	HEX.DAT
12 - Road data	RHEX.DAT
13 - River data	VHEX.DAT
14 - System list	SYSTEM.DAT

15	- Red equipment list	REQUIP.DAT
16	- Green equipment list	GEQUIP.DAT
17	- Red unit list	REDUNIT.DAT
18	- Green unit list	GRNUNIT.DAT
19	- Compatibility table	TABLE.DAT
20	- Combat outcomes table	TABLE2.DAT
21	- Key objectives	KEY.DAT
25	- System and map blackboarc	SYSBRD.DAT
26	- Red blackboard	REDBRD.DAT
27	- Green blackboard	GRNBRD.DAT

Entries:

Subroutine OPNCTL

SUBROUTINE INITIAL ()

File: UMPFILE.FOR

Purpose and Method:

This routine allows the Umpire to build new initial equipment lists for the Red and Green forces.

For each system, output name and number available. Input number allocated to Green forces and add to equipment list, setting equipment name equal to system name, and setting other variables as appropriate. Ask whether the equipment is to be operated at full or reduced readiness. Repeat for Red forces. Adjust number available. Set sentinels.

Major Variables

rnum/gnum - integer; number of items of each syster to out in list

rcount/gcount - integer; total number of items on list

Common Variables Changed

rmode/gmode ritem/gitem

redeq/grneq	rrom/grom
noa	

Common Variables Referenced but Not Changed:

system

Entries:

Subroutine INPUT

SUBROUTINE UNITLST ()

File: UMPFILE.FOR

Purpose and Method:

This routine allows the Umpire to set up the opposing forces.

Input unit names until sentinel is entered. Enter the Green JTFHQ name first, then other Green units. For each unit other than the JTFHQ, determine type of unit and set GFORCE and GUMOB accordingly. Enter location; set initial goal to stationary (0,0); set combat points to default. Based on type of unit, set air defense, close air support, counter air, ew, and combat values. Repeat for Red forces.

Common Variables Changed:

redunt/grnunt	rgoal/ggoal	rewv/gewv
rforce/gforce	rcmbtp/gcmbtp	owner
rumob/gumob	radno/gadno	lasown
rrow/grow	rcasv/gcasv	
rcol/gcol	rcav/gcav	

Subprogram calls:

Subroutine CHECK

Entries:

Subroutine INPUT

SUBROUTINE OPINTEL ()

File: UMPFILE.FOR

Purpose and Method:

This subroutine provides players with intelligence information according to the satellite survey corridors and recce flights requested in the previous turn, and from ew equipment that is in the ESM mode.

For each Red Tactical Air Wing, check C3EXT. If comm is up, check each hex in listed path for enemy units and write msg to appropriate player. Do same for Green TFWs. For each Red intelligence satellite, check to see if the JTFHQ has connectivity to NCA to receive the data (if a random number is less than NCACON). Then find the indicated column and use the crng to determine the beamwidth; then survey those columns for enemy units. For Red EW equipment in the ESM mode, check compatibility and range to enemy transmitters. Do same for Green equipment.

Major Variables:

row,col - integers; hex being inspected

iangle - integer; rounded value of bearing from ESM equipment to enemy emitter

rn - real; random number

rcomm/gcomm - real; external comm effectiveness of air wing flying recon; ability to pass recon information to HQ

rnca/gnca - real; connectivity to NCA; ability to

connect to conus to request and receive satellite intelligence

rng - integer; distance from air wing to JTFHQ

div - real; interim value used in calculating iangle

power - integer; ability of ESM to overcome security of comm systems

airpow - integer; total combat power of air wing

ray - logical; flag indicating an ESM system has detected a comm system

x - logical; true if ew system is effective against a given comm system

Common Variables Referenced but Not Changed:

redunt/grnunt	reqrow/geqrow	rcav/gcav
rforce/gforce	reqcol/geqcol	rewv/gewv
rrow/grow	rtcrng/gtcrng	owner
rcol/gcol	ricol/gicol	etype
rpathr/gpathr	rcmbtp/gcmbtp	esm
rpathc/gpathc	rmode/gmode	sec
redeq/grneq	rcasv/gcasv	seed
ritem/gitem	rtc3e/gtc3e	

Subprograms Called:

Subroutine RLISTEN/GLISTEN
Integer function RANGE
Real function C3EXT
Real function NCACON
Logical function COMPAT
System functions RAN, ABS, ATAN, and IFIX

Entries:

Subroutine OPNCTL

SUBROUTINE EWCHECK ()

File: UMPFILE.FOR

Purpose and Method:

This subroutine checks each piece of EW equipment in the ECM mode and determines if it is an effective jammer against any enemy comm equipment. It then adjusts the temporary c3 effectiveness of the affected comm gear.

Check Red equipment lists for EW equipment in ECM mode. Check enemy comm gear for range and compatibility with EW gear. If effective, adjust temporary C3 effectiveness of enemy gear by an amount proportional to the ECM value of the EW equipment. Repeat for Green EW equipment.

Major Variables:

diff - integer; difference between ew factor and security factor of EW and comm equipment

rng - integer; range from EW to comm equipment

x - logical; true if EW system is effective against comm

Common Variables Changed:

rtc3e/gtc3e
rtc3es/gtc3es

Common Variables Referenced but Not Changed:

redeq/grneq	rtcrng/gtcrng	ecm
ritem/gitem	reqrow/geqrow	ewf
rmode/gmode	reqcol/geqcol	ecm
etype	seed	sec

Subprograms Called:

Integer function RANGE
Logical function COMPAT
System functions RAN and IFIX

Entries:

Subroutine COMBAT

SUBROUTINE CA (RATTRT,GATTRT,RRESLT,GRESLT)

File: UMPFILE.FOR

Purpose and Method:

This routine calculates the outcome of counter air (air-to-air) battles when air forces of one side, enroute to their missions, are intercepted by air forces of the other side.

Total counter air value of Red air forces. Total counter air value of Green air forces. Calculate score of air battle as the difference between counter air values of the forces. Based on score and random number, determine with internal tables (Figure A-8 of Users' Manual) which air forces are attritred, whether the other missions continue or abort, and whether counter air capability is decreased.

Parameters:

rattrt/gattrt - logical; true if air forces sustain losses in the air battle

rreslt/greslt - logical; true if mission is to continue, false if it must be aborted

Other Major Variables:

rcat/gcat - integer; total temporary air value of one side

comm - real; internal C3 effectiveness of air unit

score - integer; score in counter-air battle

rn - real; random number

irn - integer; random integer

Common Variables Changed:

rtcav/gtcav

rcav/gcav

Common Variables Referenced but Not Changed:

redunt/grnunt	rrow/grow
seed	rcol/gcol

Subprograms Called:

Real function INTC3
System functions RAN and IFIX

Entries:

Subroutine DICTION
Subroutine RSTRIKE/GSTRIKE

SUBROUTINE DICTION (FIRST)

File: UMPFILE.FOR

Purpose and Method:

This module deducts recce flights from other air capability of each side and determines if interdiction strikes are permitted.

If any recce missions were flown, subtract them from the total number of interdictions that can be flown. If any interdiction capability remains, and missions were requested, then check to see if rules of engagement require approval from NCA. Call up strikes. Since recce flights take priority over all other air missions, if there are still recce missions not accounted for (they outnumbered the interdiction missions) decrease the temporary close air support value and counter air value of the air forces. Repeat the process for Green missions.

Parameters:

first - integer; number indicates rules of engagement

Other Major Variables:

rn - real; random number

comm - real; connectivity to NCA

strikr - character*3; attacker

strikes - integer; number of strikes possible

Common Variables Changed:

rrecce/grecce	rtcasv/gtcasv
rintd/gintd	rtcav/gtcav
rtintd/gtintd	

Common Variables Referenced but Not Changed:

redunt/grnunt	rrow/grow
seed	rcol/gcol

Subprograms Called:

Subroutine RLISTEN/GLISTEN
Subroutine RSTRIKE/GSTRIKE
Real function NCACON
System function RAN

Entries:

Subroutine OPNCTL

SUBROUTINE RSTRIKE/GSTRIKE (FIRST)

File: UMPFILE.FOR

Purpose and Method:

This routine determines the results of any approved interdiction missions.

If the enemy has AWACS, conduct counter air before the interdiction mission. If attrition results from counter air (see Subroutine CA), reduce effectiveness of the offensive air unit by reducing the EW value. Notify payer if mission must be aborted. If mission is not aborted, determine if any enemy units are in the target area. Conduct ground air defense by contrasting the EW value of the aircraft with the air defense value of the ground unit. Use an internal table (Figure A-9 of the Users' Manual) to compare the difference with a random number. If interdiction attack gets through the counter air and air defense, stop movement of enemy forces and attrit them by reducing their combat points by 1.0. If AWACS was not available to the enemy, conduct counter air after the interdiction.

Parameters:

first - integer; rules of engagement

Other Major Variables:

rn,rn2,rn3 - real; random numbers

irn - integer; integer random number

ad - integer; air defense results

rattrt/gattrt - logical; true if forces incur losses in air-to-air battle

rreslt/greslt - logical; rrue if interdiction mission can continue, false if it must abort

comm - real; external connectivity of air wing and later internal connectivity

rng - intger; range from air wing to JTFHQ

go - logical; true if all comm checks work

Common Variables Changed:

rgoal/ggoal	rewv/gewv
rcmbtp/gcmbatp	

Common Variables Referenced but Not Changed:

redunt/grnunt	rtintd/gtintd	radno/gadno
rrow/grow	rintd/gintd	rforce/gforce
rcol/gcol	ravalw/gavalw	seed

Subprograms Called:

Subroutine RLISTEN/GLISTEN
Subroutine CA
Integer function RANGE
Real function C3EXT
Real function INTC3
System functions RAN and IFIX

Entries:

Subroutine DICTION

SUBROUTINE COMBAT (FIRST)

File: UMPFILE.FOR

Purpose and Method:

This subroutine does any anti-satellite firings and initiates combat between enemy units. Priority for attacks goes to Red or Green randomly, then proceeds according to the value of the conflict list (units arriving last and wanting to attack, then units arriving first and wanting to attack). The subroutine also calls Subroutine EWCHECK to adjust temporary C3 and range values for jamming.

Fire any anti-satellite weapons requested by comparing a random number to the C3E of the anti-satellite weapon. Call EWCHECK. Determine randomly whether Red or Green has first chance to attack. Determine order of attacks based on conflict lists, and call appropriate attack module. Write message to player if any defensive units were not attacked. Reverse order if Green is given first chance to attack. Outcome of ground combat is determined in RATTACK/GATTACK and FIGHT subroutines.

Parameters:

first - integer; rules of engagement

Other Major Variables:

rn - real; random number

hit - logical; true if an attack approval has been requested

side - character*5; red or green

Common Variables Changed:

rtc3e/gtc3e	rweapn/gweapn
rcmbtp/gcmbtp	rtargt/gtargt
raunit/gaunit	rcnlst/gcnlst

Common Variables Referenced but Not Changed:

redunt/grnunt
redeq/grneq
seed

Subprograms Called:

Subroutine EWCHECK
Subroutine RATTACK/GATTACK
Subroutine RLISTEN/GLISTEN
System function RAN

Entries:

Subroutine OPNCTL

SUBROUTINE RATTACK/GATTACK (I,FIRST,HIT)

File: UMPFILE.FOR

Purpose and Method:

This routine determines if connectivity exists to get approval for an attack.

Identify hexes adjacent to unit. Determine if any enemy unit is in range for an attack. Check internal communications of unit. Check external communications. If rules of engagement require NCA approval of attacks, check connectivity to NCA. Ask Umpire if he wants NCA to approve attack. If rules of engagement allow JTF approval of attack, NCA connectivity check is not required. If local commanders have attack authority, only the internal comm check is required. If approved, begin attack; otherwise give enemy the opportunity to attack. If attack was aborted because of lack of connectivity, notify player and adjust combat points. Notify player if there is no longer an enemy unit in the area.

Parameters:

i - integer; index number of attacking unit

first - integer; rules of engagement

hit - logical; true if opponent is given opportunity to attack

Other Major Variables:

battle - integer; 2 if attack is aborted for lack of

connectivity

comm - real; connectivity to NCA, then external c3, then internal c3 of attacking unit

r,c,lf,rt,up1,up2,dn1,dn2 - integers; hex numbers of unit location and adjoining hexes

rng - integer; distance from unit to JTFHQ

rn - real; random number

Common Variables Changed:

rcnlst/gcnlst
rcmbtp/gcmbtp

Common Variables Referenced but Not Changed:

redunt/grnunt	rrow/grow
seed	rcol/gcol

Subprograms Called:

Subroutine RATTACK/GATTACK (call each other)
Subroutine RBATTLE/GBATTLE
Subroutine RLISTEN/GLISTEN
Integer function RANGE
Real function NCACON
Real function C3EXT
Real function INTC3
System function RAN

Entries:

Subroutine COMBAT
Subroutine RATTACK/GATTACK (each called by the other)

SUBROUTINE RBATTLE/GBATTLE (I,J)

File: UMPFILE.FOR

Purpose and Method:

This subroutine computes the effect of ESM and terrain on combat value as one unit attacks an enemy unit; it calls subprograms to compute losses due to close air support and ground combat.

Compute effect of ESM on Red combat value by subtracting the EW factor of the EW equipment from the security factor of the enemy's communications equipment and then comparing the difference to a random number. If the difference is greater, add the ESM value of the EW equipment to the combat points of the Red unit. Compute effect of ESM on Green combat value. Compute effect of terrain on attacking unit and defending unit, including additional combat points for mountains, woods, and cities which provide good cover for the forces. Add points if the defensive forces are behind a river. Call for close air support for attacking side. Output combat value entering ground combat phase. Call for ground combat (see Subroutine FIGHT).

Parameters:

i - integer; index number of attacking unit

j - integer; defending unit

Other Major Variables:

rng - integer; distance between units

rn - real; random number

irn - integer; random integer

diff - integer; difference between EW factor and security factor of EW and comm equipment

rtpnt/gtpnt - real; temporary combat points, adjusted

for terrain and esm

x - logical; true if ESM equipment is effective against comm equipment

row,col - integer; location of unit i

r,c - integer; location of unit j

Common Variables Referenced but Not Changed:

redunt/grnunt	raunit/gaunit	ewf
rrow/grow	ritem/gitem	sec
rcol/gcol	rmode/gmode	esm
redeq/grneq	rtcrng/gtcrng	hex
reqrow/geqrow	rcmbtp/gcmbtp	vhex
reqcol/geqcol	etype	seed

Subprograms Called:
Subroutine RCAS/GCAS
Subroutine FIGHT
Subroutine RLISTEN/GLISTEN
Integer function RANGE
logical function COMPAT
System functions RAN and IFIX

Entries:

Subroutine RATTACK/GATTACK

SUBROUTINE FIGHT (SIDE,I,J,RTPNT,GTPNT)

File: UMPFILE.DAT

Purpose and Method:

This subroutine computes the outcome of ground combat between Red unit I and Green unit J.

Compute difference in combat points. Check TABLE2 (Attachment A-11 to the Users' Manual) for combat outcomes, based on the difference in combat points and on a random number. Assign outcomes to appropriate sides. Output losses. If outcome table indicates retreat is necessary for

Red forces, move them back along approach path. Do same for Green retreat. If outcome table indicates Red comm losses result, locate equipment with lowest security factor(sec) and change C3 effectiveness to zero. Do same for Green comm losses.

Parameters:

side - character*1; attacking side, Red or Green

i - integer; index number of Red unit

j - integer; index number of Green unit

rtpnt/gtpnt - real; temporary combat points

Other Major Variables:

diff - integer; integer difference between combat values of the units

rn - real; random number

irn - integer; random integer

gone - integer; index number of comm equipment with lowest security factor; rendered unusable in the battle

rloss/gloss - integer; losses in combat

rret/gret - integer; number of hexes unit must retreat

rcl/gcl - integer; number of comm equiment items rendered unusable

aloss - integer; attacker's loss

dloss - integer; defender's loss

aret - integer; number of hexes attacker retreats

dret - integer; number of hexes defender retreats

acl - integer; number of comm systems attacker loses

dcl - integer; number of comm systems defender loses

mvpnts - real; movement points of unit

min - integer; minimum security value of assigned equipment

Common Variables Changed:

rcmbtp/gcmbtp	rtc3e/gtc3e
rgoal/ggoal	rtc3es/gtc3es
raunit/gaunit	

Common Variables Referenced but Not Changed:

redunt/grnunt	rpathr/gpathr	ritem/gitem
rforce/gforce	rpathc/gpathc	sec
rrow/grow	rstart/gstart	table2
rcol/gcol	redeq/grneq	seed

Subprograms Called:

Subroutine MVMENT
Subroutine RLISTEN/GLISTEN
System functions RAN and IFIX

Entries:

Subroutine RBATTLE/GBATTLE

<u>SUBROUTINE RCAS/GCAS</u> (I,J,RTPNT,GTPNT)

File: UMPFILE.FOR

Purpose and Method:

This subroutine computes the effect of close air support on enemy ground forces.

Find air unit with close air support value remaining. Compute air defense outcome by comparing the EW value of the aircraft with the air defense value of the ground unit. Use an internal table (Figure A-9 of the Users' Manual) to compare the difference with a random number. If CAS aircraft get through enemy air defenses, compute effectiveness against enemy ground forces by

checking the internal communications effectiveness of the air unit. If INTC3 is greater than a random number, decrease the ground unit combat value by 1.0.

Parameters:

i - integer; index number of attacking unit

j - integer; index number of defending unit

rtpnt/gtpnt - real temporary combat values

Other Major Variables:

rn - real; random number

irn - integer; random integer

ad - integer; air defense outcome

comm - real; internal c3 effectiveness of air wing providing close-air-support

done - logical'; true when cas has been provided by one wing; prevents dubplication of effort by another wing

Common variables changed:

rewv/gewv rcmbtp/gcmbtp
rgoal/ggoal

Common Variables Referenced but not Changed:

redunt/grnunt rtcasv/gtcasv
rrow/grow radno/gadno
rcol/gcol seed

Subprograms Called:

Subroutine RLISTEN/GLISTEN
Real function INTC3
System functions RAN and IFIX

Entries:

Subroutine RBATTLE/GBATTLE

SUBROUTINE ENDWAR (OVER)

File: UMPFILE.FOR

Purpose and Method:

This subroutine determines whether either side has won the war in a decisive victory. If not, it gives status to the Umpire and allows the Umpire to decide whether to artificially declare an end to the war with or without a marginal wictory for one side.

Determine if either side controls the major objectives by checking the last owner of hexes listed in KEYA. Determine if either side controls the minor objectives in the same way, using hexes listed in KEYB. If the same side controls both major and minor objectives declare them the decisive victors and end the game. If one side controls the major objectives and the other side controls no minor objectives, the first side has a marginal victory. Allow the Umpire to decide whether to end the game. If one side controls all major objectives but the enemy controls any minor objectives, the outcome is indecisive. Allow the Umpire to decide whether to end the game and whether to declare the first side a winner. If neither side controls the major objectives, there is no winner. Allow the Umpire the option of ending the game in a ceasefire.

Parameters:

over - logical; true if controller decides to end game or if one side has achieved victory

Other Major Variables:

row,col - integers; location of a key objective

major - character*1; side which controls major objectives

minor - character*1; side which controls minor objectives

winner - character*5; side which is winning or ahead

Common Variables Referenced but not Changed:

keya lasown
keyb

Subprogram Calls:

Subroutine RPOSIT/GPOSIT
Subroutine RLISTEN/GLISTEN

Entries:

Subroutine OPNCTL

SUBROUTINE SETOWN ()

File: UMPFILE.DAT

Purpose and Method:

This module sets the OWNER and LASOWN maps to indicate the presence of a newly established unit, designated by the Red or Green Player.

Mark new Red units. Do same for Green. Reinitialize variables to zero for next turn.

Common Variables Changed:

owner rown/gown
lasown rlas/glas

Entries:

Subroutine OPNCTL

SUBROUTINE RULES (FIRST)

File: UMPFILE.FOR

Purpose and Method:

This module allows the Umpire to review and change the rules of engagement.

Write current rule. Ask if rule should be changed; output menu of possible rules.

Parameters:

first - integer; rule of engagement

Entries:
Subroutine OPNCTL

SUBROUTINE MVMENT (I,ROW,COL,NROW,NCOL,MVPNTS,SIDE,FORCE, CNFLCT)

File: GENERAL.FOR

Purpose and Method:

This subroutine moves a unit from one hex to the adjacent hex if the unit has sufficient movement points. It calls Subprogram ENEMY to detect enemy units in adjacent hexes.

Compute number of points required for the move. If the unit has sufficient movement points, make the move, changing the OWNER array if no units from the same side remain in the old hex. Check for enemy units. Set OWNER and LASOWN arrays to indicate presence of unit.

Parameters:

i - integer; index number of unit

row,col - integers; location of unit

nrow,ncol - integers; new location of unit

mvpnts - real; movement points of unit

side - character*1; side unit is on

force - character*5; type of unit

cnflct - logical; true if enemy unit is in same or adjacent hex (to nrow,ncol)

Common Variables Changed:

owner
lasown

Subprograms Called:

Subroutine ENEMY
Real function PNTS

Entries:

Subroutine FIGHT
Subroutine RMOVE/GMOVE

<u>SUBROUTINE ENEMY</u> (ROW,COL,SIDE,CNFLCT)

File: GENERAL.FOR

Purpose and Method:

This subroutine surveys HEX(row,col) and adjacent hexes for enemy units.

Identify adjacent hexes and initialize logical to false. Survey hexes; if owner is other side or both, set logical.

Parameters:

row,col - integers; center hex

side - character*1; side doing check

cnflct - logical; true if other side is present

Other Major Variables:

iu,id,ius,ids,jl,jr - integers; row or column of adjacent hexes

Common Variables Referenced but not Changed:

owner

Entries:

Subroutine FIGHT
Subroutine MVMENT
Subroutine RMOVE/GMOVE

REAL FUNCTION PNTS (SIDE,I,ROW,COL,NROW,NCOL,FORCE)

File: GENERAL.FOR

Purpose and Method:

This function computes the movement points necessary for a unit to move to an adjacent hex.

Get points required to move into a hex of that terrain type from internal data. Adjust by adding one point if the unit must cross a river (if VHEX total of the two hexes is three). Adjust if the unit is moving along a road (if RHEX of both hexes is 1). Check type of unit for sea vs land movement. For air travel, terrain has little effect. When called from RECON module, to set photo recon route, set all hex movement points equal. When called from TERAIN module to establish line-of- sight, set all movement points equal to get nearest possible to straight line.

Parameters:

side - character*1; side moving

i - integer; index number of unit moving

row,col - integers; present location

nrow,ncol - integers; proposed location

force - character*5; type of unit

Other Major Variables:

river - integer; total vhex points of the two hexes; a 3 indicates crossing the river

points - real, number of points required for the move

Common Variables Referenced but not Changed:

hex	rhex
vhex	rseal/gseal

Entries:

Subroutine MVMENT

SUBROUTINE SYSOUT ()

File: GENERAL.FOR

Purpose and Method:

This routine writes all common map and system variables to file #25 for later access.

Common Variables Referenced but not Changed:

References(writes) all common variables from hex, rhex, system, sysacq, sysops, table, table2, and game commons

Entries:

Subroutine OPNCTL

SUBROUTINE REDOUT ()

File: GENERAL.FOR

Purpose and Method:

This module writes all common red variables to file #26 for later access.

Common Variables Referenced but not Changed:

References(writes) all variables from redunt, redpos, redeq, reqpos, and redwar commons.

Entries:

Subroutine OPNCTL
Subroutine REDOPS

SUBROUTINE GRNOUT ()

File: GENERAL.FOR

Purpose and Method:

This module writes all common green variables to file #27 for later access.

Common Variables Referenced but not Changed:

References(writes) all variables from grnunt, grnpos, grneq, geqpos, and grnwar commons.

Entries:

Subroutine OPNCTL
Subroutine GRNOPS

SUBROUTINE SYSBRD ()

File: GENERAL.FOR

Purpose and Method:

This routine reads SYSBRD.DAT (file #25) into the common variables. The formats are the same as for SYSOUT.

Common Variables Changed:

Changes all variables from hex, rhex, vhex, system, sysacq, sysops, table, table2, and game commons.

Entries:

Subroutine OPNCTL
Subroutine REDOPS/GRNOPS

SUBROUTINE REDBRD ()

File: GENERAL.FOR

Purpose and Method:

This module reads REDBRD.DAT (file #26) into the common variables. The formats are the same as for REDOUT.

Common Variables Changed:

Changes (reads) all variables from redunt, redpos, redeq, reqpos, and redwar commons.

Entries:

Subroutine OPNCTL
Subroutine REDOPS/GRNOPS

SUBROUTINE GRNBRD ()

File: GENERAL.FOR

Purpose and Method:

This module reads GRNBRD.DAT (file #27) into the common variables. The formats are the same as for GRNOUT.

Common Variables Changed:

Changes (reads) all variables from grnunt, grnpos, grneq, geqpos, and grnwar commons.

Entries:

Subroutine OPNCTL
Subroutine REDOPS/GRNOPS

INTEGER FUNCTION RANGE (I,J,K,L)

File: GENERAL.FOR

Purpose and Method:

This function computes the distance (in hexes) between two points and converts to an integer.

Parameters:

i,j - integers; first location k,l - integers; second location

Other Major Variables:

rng - integer; distance between two locations

vert - real; vertical distance

horz - real; horizontal distanc

Subroutines Called:

System functions FLOAT, SQRT, and IFIX

Entries:

General Utility

REAL FUNCTION NCACON (SIDE,ROW,COL)

File: GENERAL.FOR

Purpose and Method:

This function computes the probability the JTFHQ can coordinate with the NCA.

Identify Red switches. For each other piece of Red equipment collocated with the JTFHQ, add it to the appropriate list and find probability it will connect to NCA, based on C3E and NCAPAT. For ground terminals, check to see if a satellite beam is in range of the terminal.

Repeat for Green equipment. Compute overall probability of a link to NCA using the formula:

NCACON = 1 - [(1 - HFPROB)*(1 - VLFPRB)*(1 - GTPROB)]

Parameters:

side - character*1; side of JTFHQ

row,col - integers; location of JTFHQ

Other Major Variables:

gtl - integer; list of gtound terminal equipment numbers

vfl - integer; list of vlf equipment numbers

hfl - integer; list of hf equipment numbers

hqsw - integer; number of switch

rng - integer; range from ground terminal to beam center of satellite

hqswp - real; probability of switching properly

vlfp - real; effectiveness of one vlf link

gtp - real; effectiveness of a satellite link

hfp - real; effectiveness of an hf link

pvlft - real; overall effectiveness of vlf links

pgtt - real; overall effectiveness of satellite links

phft - real; overall effectiveness of hf links

q - real; 1-chance of some link to NCA working

satrng - logical; true is a satellite is in range

x,y - logicals; true if systems are compatible

Common Variables Referenced but not Changed:

redeq/grneq	raunit/gaunit	etype
ritem/gitem	rtc3e/gtc3e	ncapat

reqrow/geqrow   rtc3es/gtc3es   beams
reqcol/geqcol   rtcrng/gtcrng

Subprograms Called:

Integer function RANGE
Logical function COMPAT

Entries:

General Utility

REAL FUNCTION C3EXT (SIDE,K,RNG)

File: GENERAL.FOR

Purpose and Method:

This function computes the probability a unit will be in communication with its JTFHQ.

For each item of Red equipment, check to identify switches at ends of link. (The unit normally would not have a switch, but the game allows the inclusion of one.) Look for Red HF, LOS, GTPROB, or TAC equipment and find probability of each forming a link. (See Subroutines HFPROB, LOSPRB, GTPROB, and TACPRB.) Do same for Green equipment. Calculate total probability of communicating with JTFHQ using the formula:

C3EXT = 1 - [(1-HFPROB)*(1-LOSPRB)*(1-GTPROB)*(1-TACPRB)]

Parameters:

side - character*1; side of unit

k - integer; unit number

rng - integer; range from unit to JTFHQ

Other Major Variables:

hfl - integer; list of hf equipment

losl - integer; list of los equipment

gtl - integer; list of ground terminals

tacl - integer; list of tactical equipment

usw - integer; index number of switch at unit, if any

hqsw - integer; index number of switch at hq

uswp - real; effectiveness of unit switch

hqswp - real; effectiveness of hq switch

hfp - real; effectiveness of an hf link

losp - real; effectiveness of an los link

gtp - real; effectiveness of a satellite link

tacp - real; effectiveness of a tactical link

phft - real; overall effectiveness of hf links

plost - real; overall effectiveness of los links

pgtt - real; overall effectiveness of satellite links

ptact - real; overall effectiveness of tactical links

q - real; 1-chance of communicating

Common Variables Referenced but not Changed:

redunt/grnunt	rtc3e/gtc3e
redeq/grneq	rtc3es/gtc3es
raunit/gaunit	ritem/gitem
etype	

Subprograms Called:

Real function HFPROB
Real function LOSPRB
Real function GTPROB
Real function TACPRB

Entries:

General Utility

<u>REAL FUNCTION HFPROB</u> (SIDE,I,K,HQSW,USW,RNG)

File: GENERAL.FOR

Purpose and Method:

This function computes the probability of a given HF equipment item linking up to the JTFHQ.

For HF equipment belonging to unit K, check for compatible HF equipment at JTFHQ, check compatibility with switches, and check range (ground and sky waves). If all requirements are satisfied for a link, the product of the C3E of the two end equipments is the probability of the link. If more than one HF link is possible, use the highest probability.

Parameters:

side - character*1; side of unit

i - integer; index of equipment item

k - integer; index of unit

hqsw - integer; index of switch at hq

usw - integer; index of switch at unit

rng - integer; distance from unit to hq

Other Major Variables:

prob - real; best effectiveness of all hf links

probt - real; effectiveness of a given link

x,y,z - logical; true if systems are compatible

Common Variables Referenced but not Changed:

```
redeq/grneq        rtcrng/gtcrng    rrow/grow
ritem/gitem        rtc3e/gtc3e      rcol/gcol
reqrow/geqrow      rtc3es/gtc3es    etype
reqcol/geqcol      crngs
```

Subprograms Called:

Logical function COMPAT
System function MIN

Entries:

Real function C3EXT

LOGICAL FUNCTION COMPAT (I,K,RNG)

File: GENERAL.FOR

Purpose and Method:

This function determines whether two pieces of equipment are compatible at a given range, based on a compatibility table (Attachment A-2f of the Users' Manual).

Parameters:

i,k - integer; index numbers of two systems

rng - integer; distance between systems

Other Major Variables:

patible - logical; true if systems are compatible

x - character*1; value from compatibility table

Entries:

General Utility

REAL FUNCTION LOSPRB (SIDE,I,K,HQSW,USW,RNG)

File: GENERAL.FOR

Purpose and Method:

This function computes the probability of a given line-of-sight equipment item linking up to the JTFHQ directly or through a single relay.

For LOS equipment collocated with unit K, look for compatible LOS equipment at JTFHQ; check compatibility with switches. If within range, link directly; otherwise, look for a ground relay. Check for an airborne relay through an ABNCP or AWACS. LOSPRB is the product of the C3Es of the end equipments and any relays.

Parameters:

side - character*1; side of unit

i - integer; index of equipment item

j - integer; index of unit

hqsw - integer; index of switch at hq

usw - integer; index of switch at unit

rng - integer; distance from unit to hq

Other Major Variables:

rangeu - integer; range from unit to relay

rangeh - integer; range from relay to hq

probt - real; effectiveness of a given los link

prob - real; best los link effectiveness

x,y,z,w,v - logicals; true if systems are compatible

Common Variables Referenced but not Changed:

redeq/grneq	rtc3e/gtc3e	raba/gaba
reqrow/geqrow	rtcrng/gtcrng	rrow/grow
reqcol/geqcol	rawa/gawa	rcol/gcol
etype		

Subprograms Called:

Integer function RANGE
Logical function COMPAT
System function MIN

Entries:

Real function C3EXT

REAL FUNCTION GTPROB (SIDE,I,HQSW,USW)

File: GENERAL.FOR

Purpose and Method:

This function computes the probability of a given ground terminal linking to the JTFHQ through a satellite.

Look for compatible satellites and check range. Check for ground terminals at JTFHQ and check compatibility and range. Find probability for each possible link by multiplying the C3E of the satellite and the C3E of the two ground terminals. If two or more links are possible, use the one with the highest probability.

Parameters:

side - character*1; side of unit

i - integer; index of equipment item

hqsw - integer; index of switch at hq

usw - integer; index of switch at unit

Other Major Variables:

rng - integer; range from ground terminal to a satellite beam center

rngu - integer; minimum range from ground terminal to beam center of a compatible satellite

rngh - integer; range from satellite beam center to JTFHQ

nprob - real; effectiveness of link through a satellite

prob - real; effectiveness of best satellite link

x,y,z,w - logicals; true if systems are compatible

Common Variables Referenced but not Changed:

redeq/grneq	rtc3e/gtc3e	rbeam/gbeam
reqrow/geqrow	rtcrng/gtcrng	etype
reqcol/geqcol	ritem/gitem	

Subprograms Called:

Integer function RANGE
Logical function COMPAT
System function MIN

Entries:

Real function C3EXT

REAL FUNCTION TACPRB (SIDE,I,RNG)

File: GENERAL.FOR

Purpose and Method:

This function computes the probability of a direct link with the JTFHQ using a given tactical comm equipment item.

Check for compatible TAC equipment at JTFHQ; check compatibility and range of the equipment. The probability for the link is the product of the C3E of the two equipments. If two or more links are possible, use the one with the highest probability.

Parameters:

side - character*1; side owning equipment

i - integer; index of equipment

rng - integer; distance from unit to JTFHQ

Other Major Variables:

probt - real; effectiveness of a tactical link

prob - real; best tactical link effectiveness

x,y,z - logicals; true if systems are compatible

Common Variables Referenced but not Changed:

redeq/grneq	rtcrng/gtcrng	rrow/grow
reqrow/geqrow	rtc3e/gtc3e	rcol/gcol
reqcol/geqcol	ritem/gitem	etype

Subprograms Called:

Logical function COMPAT
System function MIN

Entries:

Real function C3EXT

<u>REAL FUNCTION INTC3</u> (SIDE,I,ROW,COL)

File: GENERAL.FOR

Purpose and Method:

This function computes the internal communications ability of a unit.

Find tactical gear assigned to the unit; adapt effectiveness for local terrain by checking internal data and multiplying the C3E of the equipment by appropriate factors. TACP is the effectiveness of each set of tactical equipment. INTC3 is the total effectiveness of all tactical equipment using the formula:

INTC3 = 1 - [(1-TACP(1))*(1-TACP(2))* ... (1-TACP(n))]

Parameters:

side - character*1; side of unit

i - integer; index number of unit

row,col - integers; location of unit

Other Major Variables:

tacl - integer; list of tactical equipment

taco - real; effectiveness of a tactical set

c3eff - real; effectiveness of a tactical set

q - real; 1- chance of communicating

prob - real; chance of internal connectivity

Common Variables Referenced but not Changed:

redeq/grneq	rrow/grow	rtc3e/gtc3e
reqrow/geqrow	rcol/gcol	etype
reqcol/geqcol	ritem/gitem	hex

Entries:

General Utility

SUBROUTINE CHECK (ROW,COL)

File: GENERAL.FOR

Purpose and Method:

This routine checks the validity of input map coordinates by making sure the row number is less than or equal to 66 and the column number is less than or equal to 60 and either both are odd or both even. If the numbers are not valid hex coordinates, the routine asks for and checks new row and column values.

Parameters:

row,col - integers; location being tested

Other Major Variables:

test - real; odd/even test value

Subprograms Called

System function FLOAT

Entries:

General Utility

SUBROUTINE RPOSIT/GPOSIT ()

File: GENERAL.FOR

Purpose and Method:

This routine displays the unit name, location, goal, and combat points for each unit. For each unit, write values presently in the common variables.

Common Variables Referenced but not Changed:

redunt/grnunt	gamtrn
rrow/grow	rgoal/ggoal
rcol/gcol	rcmbtp/gcmbtp

Entries:

Subroutine RTURN/GTURN
Subroutine ENDWAR

SUBROUTINE RTERAIN/GTERAIN ()

File: GENERAL.FOR

Purpose and Method:

This subroutine adjusts the temporary range and C3 effectiveness of comm equipment based on terrain.

Set temporary values initially equal to basic values for that equipment type. If the equipment is ground equipment adjust for basic terrain (excluding mountains). Check path from equipment to JTFHQ for mountains (use optimum path to simulate line of sight). If hills/mountains are at least two hexes wide and closer than three hexes, adjust comm effectiveness by a factor of 0.75.

Major Variables:

re,ce - integers; location of equipment

rb,cb - integers; location of blocking mountain

begin - integer; start of path for mountain check

Common Variables Changed:

```
rtc3e/gtc3e          rtcrng/gtcrng
rtc3es/gtc3es
```

Common Variables Referenced but not Changed:

```
readeq/grneq      rpathr/gpathr      crng
reqrow/geqrow     rpathc/gpathc      crngs
reqcol/geqcol     rstart/gstart      c3e
rrow/grow         ritem/gitem        c3es
rcol/gcol         raunit/gaunit      hex
etype
```

Subprograms Called:

Subroutine OPTIM
Integer function RANGE

Entries:
Subroutine RTURN/GTURN
Subroutine RCOMM1/GCOMM1

SUBROUTINE OPTIM (SIDE,K,ROW,COL,NROW,NCOL,FORCE)

File: GENERAL.FOR

Purpose and Method:

This routine uses a variation of the Dijkstra Algorithm [Ref. 7] to find the shortest distance from the current position to the destination. It takes into account the type of unit and the terrain by call Subroutine PNTS. The path will not allow ground units to cross lakes or seas or ships to cross land. Ground units will go through passes or over mountains, whichever requires fewer points.

Check validity of destination for type of unit. Set initial values of arrays, map borders, and origin (starting point). For present node, find additional points necessary for given force to go to each adjacent hex. Find the unexplored node closest to the origin; this is the next node to be explored. Move to next node. Trace path back from destination to origin. Reverse path and set the array element after the destination equal to zero.

Parameters:

side - characte*1; side looking for path

k - integer; index of unit

row,col - integers; present location of unit

nrow,ncol - integers; destination

force - character*5; type of unit

Other Major Variables:

er,ec - integers; E array for algorithm; calling hex

d - real; D array; path length from origin

f - integer; F array; 0 for unexplored nodes, 1 if explored

min - real; minimum distance to next node

bpathr,bpathc - integers; reverse path form destination back to origin

nextr,nextc - integers; next node to be explored

up,dn,us,ds,ls,rs - integers; coordinates of adjacent nodes

rr,cc - integers; temporary holding for r and c

r,c - integers; present node

nr,nc - integers; one hex from goal

dist - real; distance to present node

distur,distul,distu,distd,distdr,distdl - real; distances to adjacent hexes

Common Variables Changed:

rpathr/gpathr	rstart/gstart
rpathc/gpathc	rend/gend
rgoal/ggoal	rlenth/glenth

Subprograms Called:

Real function PNTS

Entries:

Subroutine REDGOAL/GRNGOAL
Subroutine RTERAIN/GTERAIN
Subroutine RRECON/GRECON

SUBROUTINE RTURN/GTURN (STOPAT)

File: RED.FOR/GREEN.FOR

Purpose and Method:

This subroutine offers a menu of possible actions, inputs the player's choice, calls the appropriate subroutine, and then loops back for another choice.

Initialize temporary values for equipment. Present player action menu.

Parameters:

stopat - real; scheduled time for end of turn

Major Variables:

choice - character*1; menu selection

airlft - logical; true if an airdrop has already been requested for this turn

Common Variables Changed:

rrecce/grecce

Subprograms Called:

Subroutine REDGOAL/GRNGOAL
Subroutine RCOMM/GCOMM
Subroutine RRECON/GRECON
Subroutine RCACAS/GCACAS
Subroutine RPOSIT/GPOSIT
Subroutine RSEALIFT/GSEALIFT
Subroutine RAIRLIFT/GAIRLIFT
Subroutine RATKSAT/GATKSAT
Subroutine RTERAIN/GTERAIN

Entries:

Subroutine REDOPS/GRNOPS

<u>SUBROUTINE REDGOAL/GRNGOAL</u> ()

File: RED.FOR/GREEN.FOR

Purpose and Method:

This routine allows the player to change the movement goal of a combat unit, displays a projected path, and allows the player to input an interim point to take another path.

Input unit name and check identity of the unit. Check communications link to see if change of orders can be sent to the unit. Display present goal of unit and ask player if he wants to change it. Ask for new goal, '0 0' to be input to stop a unit in its present position. Output new goal and proposed path. If the unit is a sealifted Marine force, the goal remains that of the Amphibious Task Force carrying the Marines.

Major Variables:

unitna - character*8; name of unit input by player

effc3 - real; effectiveness of comm link to JTFHQ

rng - integer; distance to hq

rn - real; random number

Common Variables Changed:

rgoal/ggoal

Common Variables Referenced but not Changed:

redunt/grnunt	rpathr/gpathr	rlenth/glenth
rrow/grow	rpathc/gpathc	rseal/gseal
rcol/gcol	rstart/gstart	seed
rforce/gforce	rend/gend	

Subprograms Called:

Subroutine OPTIM
Real function C3EXT
Real function NCACON
System function RAN

Entries:

Subroutine RTURN/GTURN

SUBROUTINE RCACAS/GCACAS ()

File: RED.FOR/GREEN.FOR

Purpose and Method:

For each air wing, the player selects the mission configuration for this turn. Mission choices are interdiction, counter air, and close air support.

Check unit list for flying wing. For each wing offer mission choice. If interdiction mission is selected, input 5 targets. If close air support or counter air missions are selected, set temporary values for the mission.

Common Variables Changed:

rtintd/gtintd	rtcasv/gtcasv
rintd/gintd	rtcav/gtcav

Common Variables Referenced but not Changed:

rforce/gforce	rcasv/gcasv
redunt/grnunt	rcav/gcav

Subprograms Called:

Subroutine CHECK

Entries:

Subroutine RTURN/GTURN

SUBROUTINE RRECON/GRECON ()

File: RED.FOR/GREEN.FOR

Purpose and Method:

This routine allows the player to request satellite survey of one or more columns of the map to find the locations of enemy units. The player can also request reconnaisance flights (at the expense of other air support).

Offer choice of satellite or air recon. If satellite recon is selected, review list of equipment for 'spy' satellites, display beam width(crng), and input westernmost column to be surveyed. If air mission is selected, input start and end points of mission and unit name of wing to fly the mission.

Major Variables:

unitna - character*8; unit name input by player; flying wing to be assigned recce mission

a,b - integers; starting point for recce flight

c,d - integers; end point of recce flight

Common Variables Changed:

ricol/gicol	rpathr/gpathr
rrecce/grecce	rpathc/gpathc
rstart/gstart	

Common Variables Referenced but not Changed:

redunt/grnunt	ritem/gitem
rforce/gforce	etype
redeq/grneq	crng

Subprograms Called:

Subroutine OPTIM
Subroutine CHECK

Entries:

Subroutine RTURN/GTURN

SUBROUTINE RAIRLIFT/GAIRLIFT (AIRLFT)

File: RED.FOR/GREEN.FOR

Purpose and Method:

Each side can airlift one airborne force each turn. The player identifies the unit. If it is located on an airfield, it is immediately moved to the new location. The airlift does not subtract from other air missions.

Indicate if airlift has already been used for this turn. Otherwise, input name of unit to be airlifted. Verify name if that of an existing, airborne unit. Check location to make sure unit is on an airfield. If all conditions are met, set variables for the drop.

Parameters:

airlft - logical; true if airlift has already been requested for this turn

Other Major Variables:

fly - integer; index used to identify whether identity of unit to be airlifted has been matched

unitna - character*8; name of unit to be airlifted

row,col - integers; drop zone location

Common Variables Changed:
rdrop/gdrop
rlift/glift

Common Variables Referenced but not Changed:

redunt/grnunt	rrow/grow
rforce/gforce	rcol/gcol

Subprograms Called:

Subroutine CHECK

Entries:

Subroutine RTURN/GTURN

SUBROUTINE RSEALIFT/GSEALIFT ()

File: RED.FOR/GREEN.FOR

Purpose and Method:

This subroutine embarks Marine forces providing their position and that of the Amphibious Task Force are appropriate. (They must be in adjacent sea and shore hexes.)

Offer choice of embarking or disembarking. If embarking, review list of sealifted forces to see if ships are available. Input unit to be sealifted and verify it is an existing Marine unit. (Allow reject to main menu.) Check to see if unit and ships are in adjacent hexes, if so set appropriate variables to embark. Output messages if sealift is not available or locations are wrong. If disembark is selected, input and verify name of unit. If unit is amphibious, verify that it is presently embarked on an ATF, and verify location of ships is along shore. If conditions are met, set variables for landing.

Major Variables:

unitna - character*8; name of unit to be sealifted

bottom,top,left,right - integers; coordinates of adjacent hexes

ships - logical; indicates availability of amphibious task force

lift - logical; indicates locations are appropriate

row,col - integers; possible landing zone

Common Variables Changed:

rseal/gseal	rgoal/ggoal
rrow/grow	rland/gland
rcol/gcol	rshore/gshore

Common Variables Referenced but not Changed:

redunt/grnunt	hex
rforce/gforce	

Entries:

Subroutine RTURN/GTURN

SUBROUTINE RATKSAT/GATKSAT ()

File: RED.FOR/GREEN.FOR

Purpose and Method:

This module allows the player to request use of an anti-satellite weapon. Connectivity to NCA is required reguardless of rules of engagement.

Major Variables:

count - integer; number of weapons available

list - integer; list of weapon indexes

scount - integer; number of satellite targets available

slist - integer; list of target indexes

comm - real; connectivity to NCA

rn - real; random number

num - integer; index number of target selected

Common Variables Changed:

rtargt/gtargt
rweapn/gweapn

Common Variables Referenced but not Changed:

redeq/grneq	etype
ritem/gitem	beams
rtc3e/gtc3e	

Subprograms Called:

Real function NCACON
System function RAN

Entries:

Subroutine RTURN/GTURN

REAL FUNCTION RPOINT/GPOINT (I,C3EFF)

File: RED.FOR/GREEN.FOR

Purpose and Method:

This function calculates the mobility points of a unit, considering the type of unit, the mobility of any comm equipment they are carrying along, and the effectiveness of their tactical communications.

Set points initially for type of unit. Make adjustment for mobility of comm gear. (If the mobility of the comm gear is less than that of the combat unit, the unit must slow down to the speed of the equipment.) If forces are sealifted, adjust mobility to be that of ships. Adjust for effectiveness of tactical comm. If INTC3 is less than a random number the movement points of the unit are multiplied by a factor of 0.5.

Parameters:

i - integer; index of unit

c3eff - real; internal comm effectiveness

Other Major Variables:

pnts - integer; value of movement points

rpnts - real; real equivalent of pnts

Common Variables Referenced but not Changed:

redunt/grnunt	rumob/gumob	mob
redeq/grneq	raunit/gaunit	seed
ritem/gitem	rseal/gseal	

Subprograms Called:

System functions RAN and FLOAT

Entries:

Subroutine RMOVE/GMOVE

SUBROUTINE RMOVE/GMOVE ()

File: RED.FOR/GREEN.FOR

Purpose and Method:

This subroutine moves each unit along the projected path toward its goal. Movement is affected by terrain and by the unit's movement points. The movement points of a unit are obtained by calling Subroutine RPOINT or GPOINT. These points are then compared by Subroutine MVMENT with the points required for that type of unit to enter the next hex. If the unit has sufficient points, the movement is made. Movement continues until the goal is reached, all movement points are used, or the unit enters the control zone of an enemy unit (in which case the player can choose to retreat, attack, or go on toward its goal).

Loop through units. If a unit is sealifted, wait to move it. If unit is debarking, set new position and check for enemy in the area. If the unit is being airdropped, set their new position and check for enemy in the area. If the unit is not sealifted or airlifted, check internal comm and calculate movement points. Move the unit until out of movement points, at goal, or in enemy control zone. If not in retreat, call MVMENT to make a one-hex movement. If in an enemy control zone, offer player choice of retreating, continuing on toward goal, going into a defensive position, or requesting approval of an attack. If in retreat, move backwards at half speed until out of movement points. Set new position of all mobile comm gear assigned to the unit. Check to see if movement should stop. If any units are sealifted, set their new position the same as their ships' position.

Major Variables:

mvpnts - real; movement points of unit

temp - real; temporary value of points; holds original points while adjustments are made for slower retreat speed

used - real; number of points used in a one hex retreat

retret - logical; indicates if unit is retreating

cnflct - logical; indicates unit is in the control zone of an enemy unit

wait - logical; there is at least one sealifted unit

wait2 - logical; the given unit is sealifted and must move with the ships

row,col - integers; landing zone for sealifted unit

Common Variables Changed:

reqrow/geqrow	rrow/grow	rdrop/gdrop
reqcol/geqcol	rcol/gcol	rlift/glift
rcnlst/gcnlst	rland/gland	owner
rstart/gstart	rshore/gshore	lasown
rgoal/ggoal		

Common Variables Referenced but not Changed:

redunt/grnunt	rseal/gseal
rforce/gforce	raunit/gaunit

Subprograms Called:

Subroutine MVMENT
Subroutine ENEMY
Subroutine RLISTEN/GLISTEN
Real function INTC3
Real function RPOINT/GPOINT

Entries:

Subroutine OPNCTL

SUBROUTINE RCOMM/GCOMM ()

File: RED.FOR/GREEN.FOR

Purpose and Method:

This subroutine allows the player to detach comm equipment from a unit and set it up as a separate fixed or mobile comm detachment. The player can also assign airborne command post orbits or change comm satellite orbits and beam locations, and change the mission assignments of electronic warfare systems.

Offer choice of actions. If ABNCP orbit change is desired and one is available for this turn, input new orbit center and change values. If player wants to detach comm equipment, input equipment and owning unit. Input new unit name for the detachment. If a unit by that name owns the equipment designated, detach the equipment, setting necessary variables. The unit type is now 'relay', the mobility is that of the equipment, the unit has no combat points, and no initial goal. If the player wants to change a comm satellite orbit and/or beam position, review the equipment list for comm satellites. Output the satellite name, present position, and beam centers; and input new centers. If the player wants to change EW system missions, list systems and get choice of modes.

Major Variables:

found - logical; true if equipment or unit is matched

arow,acol - integers; orbit locations of ABNCP

goback - logical; true if input equipment of unit is not found in lists

Common Variables Changed:

redunt/grnunt	reqrow/geqrow	raba/gaba
rrow/grow	reqcol/geqcol	rforce/gforce
rcol/gcol	raunit/gaunit	rcmbtp/gcmbtp
rumob/gumob	rbeam/gbeam	rmode/gmode
rgoal/ggoal		

Common Variables Referenced but not Changed:

ravalb/gavalb	rab/gab	mob
redeq/grneq	rabl/gabl	beams
ritem/gitem	etype	seed

Subprograms Called:

Subroutine CHECK
System function RAN

Entries:

Subroutine RTURN/GTURN

SUBROUTINE RCOMM1/GCOMM1 ()

File: RED.FOR/GREEN.FOR

Purpose and Method:

This subroutine is called only on the first turn of the Operations portion of the game. It allows the player to make initial allocation of comm equipment to a combat unit, fixed location, or mobile comm relay detachment.

List all equipment assigned to the player. For each equipment item, individually, determine type of equipment. If it is an ABNCP or AWACS, simply list it for later reference. If equipment is a satellite, identify the nomenclature, number of beams and beamwidth. Allow the player to input the center of each beam. If the equipment is an Intelligence satellite, identify it to the player; missions will be assigned in RECON module. If the equipment is an anti-satellite weapon, identify it to the player. Missions will be assigned in ATKSAT module. For fixed equipment, allow player to input the location. For mobile equipment, allow player choice of assigning to a particular combat unit or setting it up as a separate comm detachment. For equipment to be assigned to a combat unit, input the unit name and set the location of the equipment to match.

For equipment to be used as a separate detachment, input the location and new unit name. Set force type to 'relay', set mobility points, combat points, and goal. If AWACS is available, calculate percentage of availability, based on the number of planes. If ABNCPs are available, calculate the percentage of availability; missions will be assigned in the COMM routine of each turn. Set temporary C3 effectiveness of equipment based on terrain at the initial location.

Common Variables Changed:

redunt/grnunt	reqrow/geqrow	raw/gaw
rforce/gforce	reqcol/geqcol	rawl/gawl
rrow/grow	raunit/gaunit	rab/gab
rcol/gcol	ravalb/gavalb	rabl/gabl
rgoal/ggoal	ravalw/gavalw	rawa/gawa
rumob/gumob	rcmbtp/gcmbtp	raba/gaba
rown/gown	rlas/glas	

Common Variables Referenced but not Changed:

redeq/grneq	etype	crnq
ritem/gitem	beams	mob

Subprograms Called:

Subroutine RTERAIN/GTERAIN
Subroutine CHECK

Entries:

Subroutine REDOPS/GRNOPS

6. PREPARING ALTERNATE GAMES

6.1 DATA BASE SETS

There are five basic data sets needed to play COMEL (Map, System Information, Equipment Lists, Unit Lists, and Combat Results Table). Any one set may be changed without changing the others. By changing the data files you can tailor the battle to match a real world batle or determine the relative value of two different electronic systems.

6.1.1 The Map

There are three sets of map data arrays and a fourth file identifying the key objectives. One array indicates the basic terrain type of each hex (open,desert, etc.); the second indicates roads; the third shows rivers. To enter a new map, you must prepare four data files, as described in Section 6.2. When you name the new files, be sure not to use the same names as the default files (HEX.DAT, RHEX.DAT, VHEX.DAT, and KEY.DAT). When the map information files are replaced the Operations Plan and Commander's Assessment (Attachments A-7 through A-10 of the Users' Manual) should also me replaced.

6.1.2 The System Information

Technical data and cost information on the electronic systems takes two files, one for the primary data and one for a compatibility table. The technical data includes the mobility, range, effectiveness, and other information. The cost data, included in the same file, gives costs and time required for development, purchase, operations, etc. The compatibility table indicates which comm systems are compatible with each other and with systems for the NCA. It also shows which EW equipment is effective against which comm systems. The system and compatibility information must match, so either both default files or both new files must be used. Section 6.3 describes in detail the format of these files. Do not use the default file names (SYSTEM.DAT and TABLE.DAT).

The file SYSINF.DEF includes general information about the systems, which can be displayed on the players' screens. This file should be replaced by a similar file for the new systems.

6.1.3 The Equipment Lists

The equipment lists show each actual, individual end item of equipment available to the Joint Task Forces. Each entry includes a link to the appropriate entry in the system file. Four default files are available, Red and Green files for the Acquisition Phase and Red and Green files for the Operations Phase. The file names for the default lists are

REQUIP.EXT, GEQUIP.EXT (for the Operations Phase), REQUIP.DEF, and GEQUIP.DEF (for the Acquisition Phase or a complete game). New equipment lists can be prepared on the editor, using the directions in Section 6.4. If only the Operations Phase is being played, the controller can also build the lists interactively at the beginning of the first game turn.

6.1.4 The Unit Lists

The unit lists indicate the combat units available to each side, with information on their mobility, initial location, and combat values. The default lists are in REDUNIT.DEF and GRNUNIT.DEF. New lists can be built in edit by following the instructions in Section 6.5, or interactively at the beginning of the Operations Phase.

6.1.5 Combat Results

The combat results table is a matrix using the difference in combat value of two units and a random number to designate the outcome of land combat. The default file is TABLE2.DEF; instructions for preparing a new file are in Section 6.6.

6.2 PREPARING A NEW MAP

The map for COMEL is made up of a 66 row, 60 column hexagonal layout. The numbering system is described in Section 1.4 of the Users' Manual. Each hex represents an area about 5 miles across, so the entire map is therefore

about 178 miles by 300 miles. To prepare a new map from a real world map, make a scaled copy of the map on appropriately sized hex paper, or overlay the map with a clear plastic overlay of the appropriate size hexes. Work in rows, identifying the area of the map in each hex as primarily open(o), mountains(m), woods(w), desert(d), lake(l), or sea(s). List the data in alternating file columns so that it makes a checkerboard pattern, as in Figure B-1.

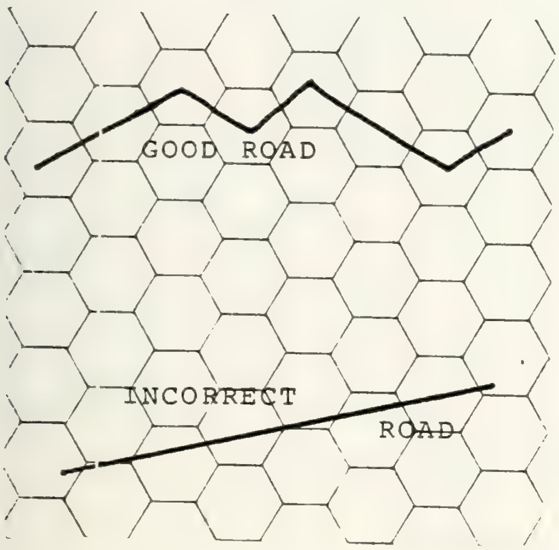
```
o o o o m a o s s s s s s s s s s s s
 o o o o m m w w o o o o o s s s s o o
o o o o m m w w w o o o o s s s s o o
 o o o o w w w w o o o o o o s o o o o
o o o o o w w w o o o o o o c c o o o
 o o o o w w w w o o o o o o c o o o o
o o o o o w w w o o o o o o o o o o o
 o o o o w w w o o o o o o o o o o o o
l o o o l l l l d d d d d d d d d d d
 l o c l l l l l d d d d d d d d d d d
l o c c l l l l d d d d d d d d d d d
 l o c l l l l d d d d d d d d d d d d
l o o o l l l l d d d d d d d d d d d
 l o o o l l l d d d d d d d d d d d d
```

HEX MAP CHECKERBOARD

Figure B-1

Next you must trace any roads you want to include. You will have to decide whether to show all roads or only major highways, depending on the density of the road system. Make a second, similar checkerboard pattern with zeros where there are no roads and '1' for hexes with roads. Make sure

that the resulting pattern makes a route that can be followed from hex to hex with no breaks (see Figure B-2).




```
 0 0 0 0
0 1 1 0
 1 1 1 1
1 0 0 1
 0 0 0 0
0 0 0 0
 0 0 0 0
0 0 0 0
 0 0 0 1
0 0 1 1
 1 1 1 0
1 1 0 0
 1 0 0 0
```

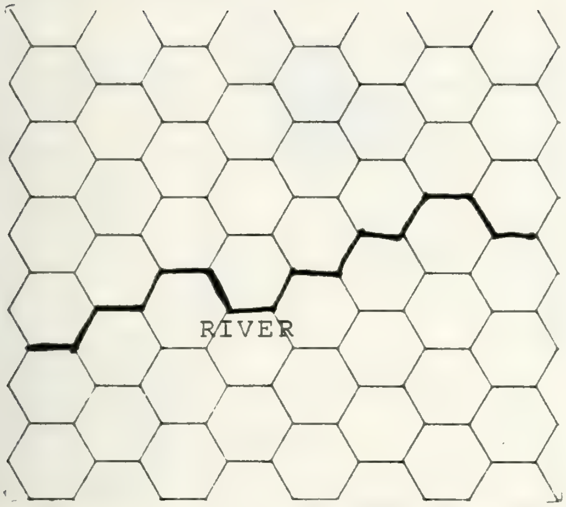
TRACING ROADS THROUGH HEXES

Figure B-2

A unit going from a '1' hex to a '1' hex is traveling along a road and can move faster.

Prepare a third checkerboard to show rivers. Rivers must appear to flow along the borders between hexes, so determine on your hex paper which route is the closest approximation of the actual path of the river. Label hexes on one bank of the river with '1' and those hexes on the opposite bank with '2', as in Figure B-3.

A unit moving between two hexes with total value of 3 must be crossing the river. If two units are fighting from adjacent hexes with a total value of 3, the river is between them and the defender has an advantage.




```
 0 0 0 0
0 0 0 0
 0 0 0 0
0 0 0 2
 0 0 2 2
0 2 2 1
 2 2 1 1
2 1 1 0
 1 1 0 0
1 0 0 0
 0 0 0 0
0 0 0 0
```

TRACING RIVERS THRUOGH HEXES

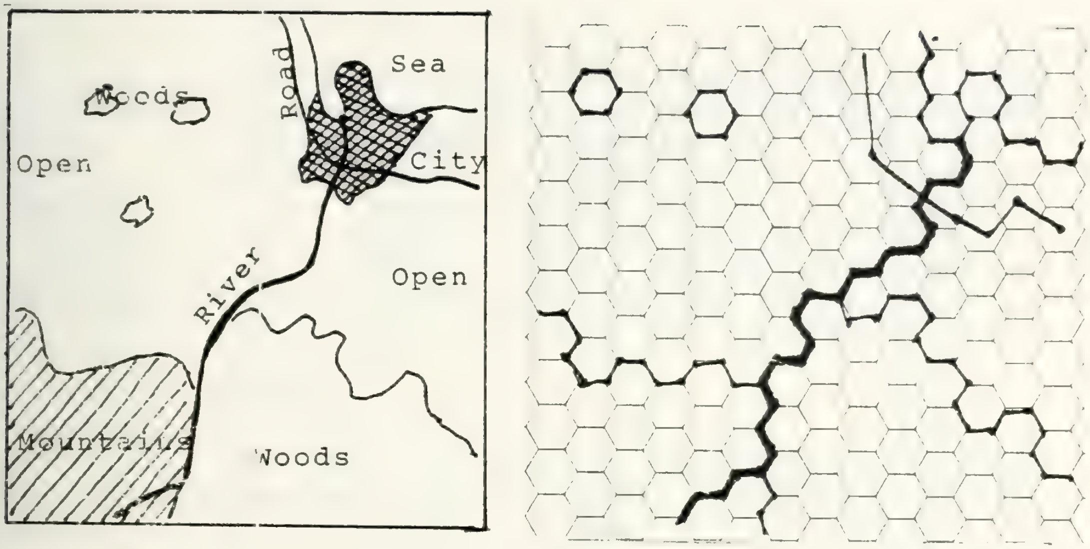
Figure B-3

Finally make a list of hexes with major and minor objectives. The list should show the major objectives (row then column in file columns 1-2 and 20-21), then sentinals (-1 -1), then the minor objectives, then sentinals. The list of objectives for the default game may be used as an example; it is in file KEY.DEF

A small portion of a map and the equivalent hex map are shown in Figure B-4.

6.3 PREPARING A SYSTEM LIST

Each system requires three lines of data in the system listing; the first line identifies the system and the general equipment type, the second has technical data, the third has cost data. The data items, measurement units,



MAP TRANSLATION

Figure B-4

data type, maximum range, a sample entry, and the file columns are as follows:

LINE 1

item	unit	data type	range	sample	columns(1)
system name	-	char*8	-	hftty 2	2-9
system type(2)	-	char*5	-	hf	10-14

Note 1: File columns are critical. Character variables should be left justified and integers right justified in the listed columns.
Note 2: System type must be one of the twelve listed in Section 1.5

LINE 2 - EW SYSTEMS

item	unit	data type	range	sample	columns(1)
mobility	hex	integer	0-999	6	4-6
range	hexes	integer	0-9999	35	9-12
EW factor	-	integer	0-20	7	17-18
ECM value	-	real	-1.0-0.0	-0.75	19-24
ESM value	-	integer	0-5	1	30

LINE 2 - HF SYSTEMS

item	unit	data type	range	sample	columns(1)
mobility	hex	integer	0-999	8	4-6
ground wave range	hexes	integer	0-9999	6	9-12
sky wave range	hexes	integer	0-9999	9999	15-18
security factor	-	integer	0-5	1	24
reliability	%	real	0.0-1.0	0.85	26-30
rel/sky wave	%	real	0.0-1.0	0.78	32-36
flexibility	%	real	0.0-1.0	0.84	38-42
optimization	%	real	0.0-1.0	0.92	44-48
C3E(3)	%	real	0.0-1.0	0.91	50-54
C3E/sky wave	%	real	0.0-1.0	0.78	56-60

Note 3: This number in the default file (See Section 2) is the product of reliability, flexibility, and operability. For communications systems, the square root of the product represents the C3E of one end of a communications link. Any method of calculating the C3Effectiveness may be used, since the C3E and C3E(sky wave) are used in the game but REL, RELS, FLEX, and OPT are not.

LINE 2 - COMMUNICATIONS SATELLITES

item	unit	data type	range	sample	columns(1)
mobility	hex	integer	999	999	4-6
beam width	hexes	integer	0-9999	6	9-12
# of beams	-	integer	1-10	4	17-18
security factor	-	integer	0-5	2	24
reliability	%	real	0.0-1.0	0.85	26-30
flexibility	%	real	0.0-1.0	0.84	32-36
operability	%	real	0.0-1.0	0.92	38-42
C3E(3)	%	real	0.0-1.0	0.91	44-48

LINE 2 - ANTI-SATELLITE WEAPONS

item	unit	data type	range	sample	columns(1)
mobility	hex	integer	999	999	4-6
range	hexes	integer	0-999	6	9-12
reliability	%	real	0.0-1.0	0.85	14-18
flexibility	%	real	0.0-1.0	0.84	20-24
operability	%	real	0.0-1.0	0.92	26-30
C3E(3)	%	real	0.0-1.0	0.91	32-36

LINE 2 - ALL OTHERS

item	unit	data type	range	sample	columns(1)
mobility	hex	integer	999	999	4-6
range	hexes	integer	0-999	6	9-12
security factor	-	integer	0-5	2	17-18
reliability	%	real	0.0-1.0	0.85	20-24
flexibility	%	real	0.0-1.0	0.84	26-30
operability	%	real	0.0-1.0	0.92	32-36
C3E(3)	%	real	0.0-1.0	0.91	38-42

LINE 3

item	unit	data type	range	sample	columns(1)
number available	-	integer	0-99	14	5-6
R&D cost	$M	integer	0-999	2	10-12
R&D time	years	integer	0-5	2	18
Accelerated R&D cost	$M	integer	0-999	4	22-24
Accelerated R&D time	years	integer	0-5	1	30
Manufacturing cost	$M	integer	0-999	7	34-36
Manuf. time	years	integer	0-5	3	42
Normal O&M cost	$M	integer	0-999	1	46-48
Reduced O&M	$M	integer	0-999	1	52-54

An example of a three-line entry for a system is:

```
 artac 1 tac
     7     3     1 0.780 0.750 0.880 0.714
     4     0     0     0     0    12     1     8     4
```

Up to 49 separate systems may be entered. After the last system, enter a '-1' in columns 2 through 3 and 10 through 11 of the next empty line. These will act as sentinals. If you wish to add a system that does not exactly match any of the system types listed, you must improvise to the closest fit. Addition of another type of system to the game would require major revision to the game (See Section 5.4.4).

A matching compatibility table must be prepared. This table is a two dimensional matrix with the row numbers and column numbers corresponding to the index numbers of the systems in the system list. Each matrix entry (i,j) tells

whether system i is compatible with system j or, in the case of an EW system, whether i is effective against j. The matrix entry is an 'n' if the systems are not compatible, 't' if they are compatible, 'w' if they are compatible only if connected by wire, and 'g' if compatible only at very short range (one hex).

A matching general information is also be needed, to be shown on the players' screens. Each system type has two to ten lines of general information on the use of the system. The default file can be used unless new system types have been added to the game.

The system information for the default game may be used as examples. The default system list is in file SYSTEM.DEF, the matching compatibility table is in TABLE.DEF, and the matching general information is in SYSINF.DEF.

6.4 PREPARING NEW EQUIPMENT LISTS

Equipment lists for the Operations Phase require only three data items (End Item Name, System Number, and Percent of Readiness).

item	unit	data type	range	sample	columns(1)
end item name	-	char*8	-	hftty 2	2-7
system #(4)	-	integer	1-49	32	8-13
% Readiness	%	real	0.0-1.0	0.85	14-19

Note 4: The system number is a link to the index of the matching system from the system list. For example, in the default game Red has 12 hftty equipment items, each of which is linked to system number 8, hftty 2.

After the last unit, enter a '-1' in the first two data columns to act as a sentinal. No more than 99 equipment items can be used for each side. The default files, REQUIP.EXT and GEQUIP.EXT can be used as examples.

6.5 PREPARING NEW UNIT LISTS

Each unit list has nine data items as follows:

LINE 1

item	unit	data type	range	sample	columns(1)
unit name	-	char*8	-	8th abn	1-8
unit type(5)	-	char*5	-	amph	14-18
row	hex	integer	1-66	42	26-27
col(6)	hex	integer	1-60	36	36-37

LINE 2

item	unit	data type	range	sample	columns(1)
mobility	hexes	integer	0-20	8	6-7
counter-air value(7)	-	integer	0-10	4	19-20
close-air-support(7)	-	integer	0-10	6	32-33
ew-value(7)	-	integer	0-10	4	44-45
air-defense value	-	integer	0-10	6	56-57

Note 5: The type must be one of the eight listed in Section 1.5; the first unit listed must be the JTFHQ.
Note 6: Location row and col must both be odd or both even.
Note 7: Air units only (tfw or cbg), 0 for all others.

A '-1' should be entered in columns 2 and 3 of the line following the last unit, to act as a sentinel. Up to 19 units can by entered for each side. The default lists are in REDUNIT.DEF and GRNUNIT.DEF.

6.6 PREPARING A COMBAT VALUE TABLE

The combat value table is a matrix with the rows being random integers from 0 through 9 (corresponding to the random numbers) and the columns being the relative difference (from -4 through 5) in combat values of two units. (The defender's combat points are subtracted from the attacker's points; if the difference is greater than 5 or less than -4 it is changed to one of those limits.) Each entry in the matrix has two groups of three integers; one group for the attacker and one for the defender. The three integers for each unit tell: (a) how many combat points the unit loses, (b) how many hexes the unit must retreat (back along the approach path), and (c) how many equipment end items are destroyed. For example, if the combat units have a difference in combat units of 2.3 (rounded to 2) and the random number is 6, the table might indicate an outcome of '1 0 0 3 2 1', meaning the attacker loses 1 combat point; the defender looses 3 points, retreats 2 hexes, and loses 1 piece of C3 equipment (the piece with the lowest security factor).

The format of the file, for random number 0, looks like this:

```
1 0 0 2 0 0  1 0 0 2 0 0  2... 0 2 0 0  2 0 0 1 0 0
 2 0 0 0 0 0  1 1 1 0 0 0  2... 2 0 0 0  9 9 9 0 0 0
```

Nine similar sets of numbers are added for the other random numbers. The default file is in TABLE2.DEF.

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